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SUDAN GOVERNMENT

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MINISTRY OF AGRICULTURE

ANNUAL REPORT
OF THE
RESEARCH DIVISION

1953/54

N.S.P
C.R.A.M.
M.S.
COMMONWEALTH MYCOLOGICAL INSTITUTE
10 AUG 1959

SUDAN GOVERNMENT

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MINISTRY OF AGRICULTURE

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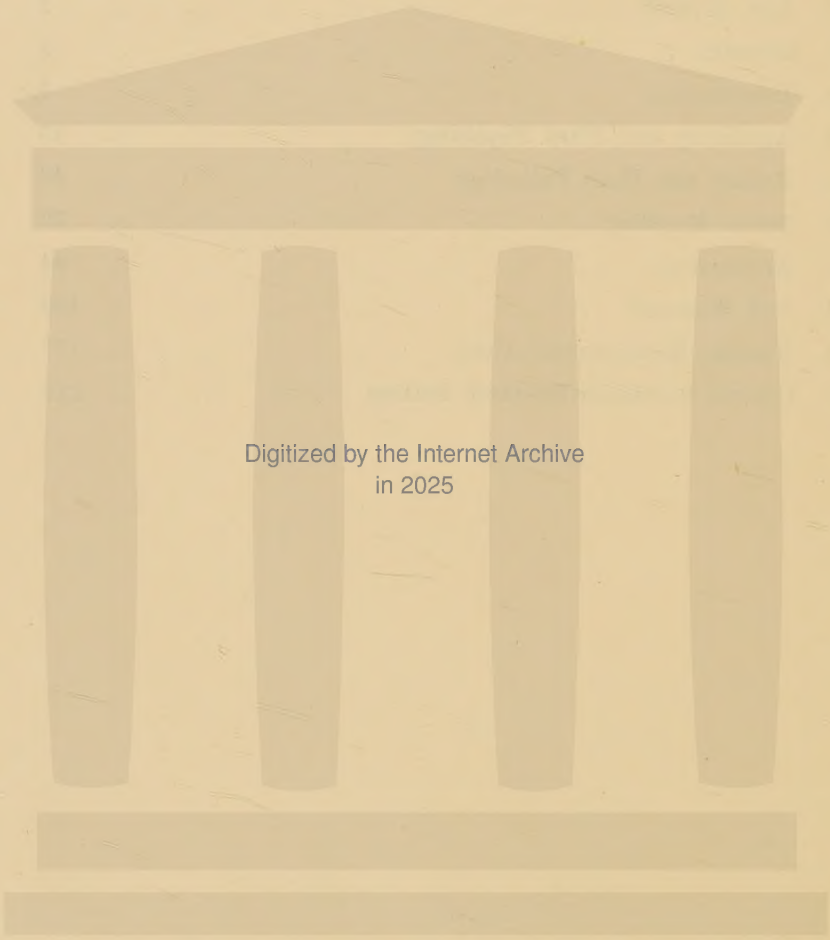
CONTENTS

		Page
1.	List of Staff	1
2.	Glossary	3
3.	Introduction	5
4.	Agronomy and Plant Physiology	15
5.	Botany and Plant Pathology	48
6.	Cotton Breeding	70
7.	Entomology	94
8.	Soil Research	159
9.	Yambio Experimental Farm	177
10.	Central Rainlands Research Station	212



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RESEARCH DIVISION.

List of Senior Staff in Season 1953/54.

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Asst. Chief and Chief Chemist	.. T. N. Jewitt, Phd.
Inspector, Administration ..	.. Amin Idris
Librarian	.. Miss. P. M. J. Edwardes
Statistician	.. P. Roberts, B.Sc.
Inspector, Plant Propagation	.. C. G. Webster

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Chief Agronomist	.. H. Ferguson, B.Sc.(Agric),N.D.A., N.D.D.
Senior Agronomist	.. S. Gray, B.Sc., Dip., Agric. Science (Kantab), A.I.C.T.A.
Agronomist	.. H. D. Fowler, B.Sc.
Plant Physiologist	.. C. Coburn, M.Sc.
Inspector, Agronomy ..	.. Khalid Salih
Farm Manager	.. (*Vacant*)

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Plant Pathologist	.. S. A. J. Tarr, B.Sc., Ph.D. (Lond)
Economic Botanist	.. K. W. Jones, M.Sc.

Cotton Breeding Section

Chief Cotton Breeder and Geneticist	R. L. Knight, O.B.E., M.Sc. (Agric) D.Sc. Ph.D., A.I.C.T.A., Dip. Agric. (Wye).
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Senior Geneticist	.. S. O. S. Dark, B.Sc., Ph.D. (Lond)
Senior Cotton Breeder ..	.. L. C. Hughes, B.Sc.
Cotton Breeder	.. A. Low, B.Sc.
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Entomologist	.. D. G. Pollard, B.Sc.
Entomologist	.. A. T. Goodman, M.Sc.
Entomologist (Locust Research)	.. H. J. Morris, M.A. (Oxon)
Inspector, Pest Control ..	.. Beshir Babikir el Shafie
Inspector, Plant Quarantine	.. Ahmed Mohammed Mekkawi

Soil Research Section.

Chief Chemist	.. T. N. Jewitt, Phd. (Cantab).
Senior Chemist	.. K. R. Middleton, M.Sc., A.R.I.C.
Senior Chemist	.. T. G. Wasowicz, Ing. Agric., (Warsaw), Dr. Agric. Sc., (Cracow)
Soil Surveyor	.. C. W. Mitchell, M.A.
Inspector, Soil Survey ..	.. Mohammed Abdel A'al

Yambio Experimental Farm.

Senior Research Officer ..	.. P. de Schlippe, A.G. (Gembloux)
Agronomist	.. K.R.M. Anthony, B.Sc., A.I.C.T.A.
Entomologist	.. E. M. McDermid, B.Sc.
Senior Chemist	.. S. G. Willimott, B.Sc., Ph.D. (Liv.), Ph.D., (Cantab), F.R.I.C.
Inspector	.. H. Lyon, B.Sc.

Central Rainlands Research Station.

Senior Research Officer ..	.. A. H. Bunting, M.Sc., D. Phil.
Entomologist	.. W. S. Richards, M.A., D. Phil.
Plant Breeder	.. P. D. Walton, B.Sc.
Agronomist	.. J. R. H. McCallum, B. Agric., Dip. Agric. (Cantab)
Botanist	.. J. D. Lea, B.Sc.
Chemist	.. (*Vacant*)
Plant Pathologist	.. P. K. S. Clinton, B.Sc.

GLOSSARY

1 Feddan	=	1.038 acres = 4200 sq. metres.
1 Rotl	=	0.99 lbs.
1 Kantar of Seed Cotton	=	315 rotls.
Abu Ashreen	=	A watering channel leading from a large canal
Abu Sitta	=	A small watering channel leading from an abu ashreen.
Angaia	=	Sub-division of a plot of land bounded by a gadwal and a tagnet.
Anis	=	The grass *Sorghum purpureo-sericeum*, Aschers and Schweinf.
Asal	=	Honey. Term used for stickiness on plants.
Beladi	=	Native.
Berseem	=	Lucerne (*Medicago sativa*).
Bildat	=	Land, usually near a village, which is cultivated for several years in succession.
Dukhn	=	Bulrush millet (*Pennisetum typhoideum*, Rich)
Dura	=	Giant millet (*Sorghum vulgare*, Pers).
Gadwal	=	The smallest watering channel, leading from an abu sitta on to the land.
Gassab	=	Dura stalks.
Goz	=	Sandhill.
Hafir	=	Pit dug in the ground to collect rain water for use in the dry season.
Harig	=	A system whereby old, dry grass is burnt to kill off germinated weeds before sowing the crop.
Hawasha Hosha	=	The unit holding in the Gezira Scheme. In the case of cotton, 10 feddans.
Kharif	=	The main rainy season.
Khor	=	Watercourse with seasonal flow.
Komodob	=	Land under crop, which also bore a crop in the previous year.
Lubia	=	The fodder bean, *Dolichos lablab*, Linn.
Number	=	Unit of land irrigated by an abu ashreen in the Gezira Scheme, usually 90 feddans.
Sagia	=	Land watered by a water wheel, or the water wheel itself.

Seluka	=	Native sowing stick.
Tagnet	=	Ridge for controlling watering.

Abbreviations.

C.R.R.S.	=	Central Rainlands Research Station.
G.R.F.	=	Gezira Research Farm.
k.p f.	=	Kantars per feddan.
r.p.f.	=	Rotls per feddan.
C.O.T.	=	Ginning out-turn (as percentage of seed cotton)
S.E.	=	Standard error.
S.G.B.	=	Sudan Gezira Board.
Y.E.F.	=	Yambio Experimental Farm.

RESEARCH DIVISION
MINISTRY OF AGRICULTURE

ANNUAL REPORT FOR 1953/54

INTRODUCTION.

General.

Dr. R. L. Knight, Chief Cotton Breeder and Geneticist, retired after 25 years service. Other retirements were Messrs. P. de Schlippe Senior Research Officer, Yambio; H. D. Fowler and C. Coburn of the Agronomy and Plant Physiology Section and D. G. Pollard, Entomologist.

Appointments were Khalid Eff. Saleh, Farm Manager; Ahmed Eff. Kordofani, Inspector Agronomy; Lloyd Eff. George, Entomologist; Mr. J. H. Saunders (E.C.G.C.), Economic Geneticist; Dr. T. E. Wasowicz, Soil Chemist; Mr. P. Roberts; Statistician.

Dr. H. L. Richardson visited the Gezira Research Farm for 2 months and did valuable work examing some of the long term experiments.

Egyptian Cotton

Yields

The yields in the past eight seasons have been as follows (in kantars of 315 rotls per feddan of seed cotton).

	1945.46	46/47	47/48	48/49	49/50	50/51	51/52	52/53	53/54
Gezira ...	3.36	3.93	3.39	4.26	4.58	6.78	3.10	4.71	4.69
A/Magid ...	3.00	3.00	3.07	4.01	4.61	5.75	2.42	4.06	3.74
Dueim ...	2.22	2.72	2.83	3.75	3.98	6.23	3.29	4.56	4.53
Fatisa ...	1.95	1.92	3.62	4.69	4.48	6.21	3.01	4.66	4.94
Hashaba ...	2.00	1.64	4.01	4.46	4.32	5.95	2.64	4.71	3.47
Um Gerr ...	2.69	3.78	3.25	4.37	4.67	6.82	3.34	4.60	4.27
Wad Nimr ...	3.32	2.83	2.91	5.81	6.37	9.30	3.57	6.95	4.49
Wakra ...							5.80	7.04	5.62
Shabasha ...							3.84	7.81	6.29
Tokar ...	2.27	1.81	2.40	1.35	1.13	1.74	0.66	1.38	1.52
Gash ...	1.52	1.81	2.20	2.23	2.30	1.42	1.67	1.45	1.07

The estimated yield of the Gezira according to the rainfall formula was 5.02 k.p.f., the highest since 1929. With additions for manuring, spraying and fallow hoeing a yield of at least 6.00 k.p.f. might have been expected. The final yield did not approach this figure and was actually substantially less than the unadjusted rainfall estimate. This is the first time that the actual yield has been lower than the estimate since 1947/48 at which time only 11 per cent of the cotton was manured and 16 per cent sprayed, compared with about 75 and 98 in 1953/54.

With the exception of 1949/50, the trend of the estimated and actual yields was the same from 1934 35 till 1952/53. But this was not so in 1953/54, the estimate being much higher than the previous season's estimate and the actual yield slightly lower than that of the previous season.

The only explanations of these 'discrepancies' which may be offered are the attack of leaf curl disease in the Sakel, which was the worst for many years, and the winter weather. Insect pests and blackarm were not particularly serious.

The area yields were :—

North Group	(all Sakel)	4.22 k.p.f.
Messellemia	($\frac{3}{4}$ Sakel)	4.44
Wad Shair	($\frac{1}{2}$ Sakel)	4.72
Centre	(1/10 Sakel)	5.31
South	(all 1730)	4.89

Abdel Magid Scheme (1730) did badly compared with the neighbouring part of the Gezira Scheme and the White Nile Schemes mostly yielded lower than in 1952/53.

The Gash Delta gave the very low yield of 1.07 k.p.f. which was attributed to bollworms.

At Tokar, the severity and persistence of the hababai wind reduced 96,000 feddans planted to 70,000 effective which yielded 1.52 k.p.f. — better than the two previous seasons.

Gezira Weather.

Rains in May and June were more than the average, July rains less and August rains more than the average. At the G.R.F. there was little rain in the second half of August but this did not apply to the commercial area, in many parts of which there was very heavy rain and flooding in the second half of August. September-October rains were less than average.

The weather was cooler than average in July and August and also in September and October. The winter began with a very cold spell from mid-November till 24 December. This was followed by 18 hot days, and then 15 cold days ending on 27th January, after which the weather was hot.

No insect pests were of notable importance in the Gezira in 1953/54. Flea beetle attack was light, thrips damage was confined to small areas in the south and jassid damage on unsprayed fields was variable. Whitefly build-up began in September but the infestation did not develop seriously except in patches. American bollworm was worse than usual but did not in, general, cause serious loss of crop. Pink bollworm was about average and much less than the previous season.

Sudan bollworm (*Diparopsis*) and Egyptian bollworm (*Earias*), mainly the former, were extremely bad in the Gash Delta and the very low yield is attributed to these pests. A large number of insecticides have been tried but none has been considered promising enough to warrant large scale trial. Flooding old cotton land is to be tried in 1954 55 to kill the pupae in the soil ; other measures against bollworms are the eradication of *Abutilon* (the only important alternate host of *Earias*) and uprooting all cotton so as to prevent the growth of ratoons on which *Diparopsis* has an early generation before the cotton crop is in a state fit for breeding on.

Work at Tokar has led to the conclusion that insects are not the basic cause of shedding which would occur whether the insects attacked the fruits or not. The shedding is thought to be due to the cloudy conditions at Tokar in the winter. In 1953, 54 there was a slight general attack of aphis and the usual severe termite damage in some areas,

Research in Gash and Tokar is not included in this report.

Since the new synthetic insecticides became available, resulting in the successful control of jassids and thereby large financial gains, entomological problems have increased. DDT spraying seems to have disturbed the ecological balance in some areas, and the control of other pests by insecticides became important. Pest Control Ltd. have had research entomologists working in the Gezira and other firms interested have recently sent out entomologists to study these problems.

In 1953/54 a committee was formed to coordinate the work of the visiting entomologists with that of the Research Division and the report by the Government Entomologist, who coordinated the work, gives the result of all this work.

A large programme of entomological experiments was carried out in the Gezira. This falls under three headings, investigation of more economical methods of using D.D.T. against jassids, investigation of the behaviour of DDT spray under various conditions and work on the cotton whitefly.

1 lb. of DDT per feddan is the quantity used for control of jassids· The experiments show that it should be safe to use $\frac{3}{4}$ or $\frac{1}{2}$ lb. of the insecticide per feddan in as small a quantity of spray as 2 galls. per feddan. Indeed it seems likely that $\frac{1}{2}$ — 1 lb. of DDT in 0.4 galls. of spray per feddan may be adequate. Control of thrips was also achieved in these trials. It was also found that satisfactory control of jassids in aerial spraying could be obtained when the swath width was increased to 70 metres ; this practice, by reducing the number of runs to be made by the aircraft, would result in considerable economy.

Investigations into the ecology of the whitefly indicate that shelter from the wind and humidity provided by a low growing bushy plant are the main factors favouring the increase of the insect. These are preliminary conclusions, as micro-climatic observations have not been made.

It has been known for some time that the single DDT spraying for jassids increases the whitefly infestation in the crop, although it kills the adult whiteflies. An experiment was carried out to test the effect of repeated spraying with DDT. The results are difficult to interpret but this insecticide is ineffective against the immature whitefly, at least unless the spray covers the leaf well. It appears, however, that 6 sprayings were necessary to reduce the whitefly population to a figure well below that of the unsprayed cotton.

Parathion had been shown in earlier experiments to be the most promising insecticide for whitefly and large scale trials were therefore made. Good control of all stages of the insect was obtained but the infestation was not heavy and the yields of the three treatments were much the same. There was a heavy infestation of American bollworm, with some *Earias*, in the parathion sprayed plots early in the season which caused a large amount of shedding of the early fruit and damage to the growing points.

The Sakel in the Gezira Scheme had the worst attack of leaf curl for many years and this must have caused a heavy loss in yield. (p. 000) The attack began early, which always means that it will be severe, and became widespread. Blackarm was negligible in the Gezira.

Blackarm and leaf curl in the Gash were worse than in 1952 53.

There was considerable bad boll opening in the Gezira particularly in the north. This was probably due to the cold weather and was doubtless accentuated by leaf curl.

Further work was done on improved seed disinfectants for blackarm and the stage has been reached when methods of large scale application of R1489 can be tried.

The treatment of cut cotton stalks with herbicides to prevent ratooning was continued but so far the percentage killed is not high enough for this method to replace uprooting.

Agronomy Experiments

G.R.F. yields were very good. That of the continuous cotton plot was the best for 11 years and 76% above its 35 years average and the two course demonstration gave record yields for all three rotations. This shows the persistance of potential fertility in Gezira soil. The Combined Rotations Experiment gave record yields except for one rotation.

Responses to nitrogenous fertilizer were exceptionally high especially in the Gezira Observation Plots at the G.R.F. and Hag Abdalla (p. 000). Ammonium nitrate "prills" gave slightly better results than other evenly spread ammonium nitrate or that spread in lumps, but the differences were not significant; placing in holes was significantly better than spreading and covering by ridging.

Following small scale work with phosphates during the last few seasons, several new field experiments were begun, mostly with nitrogen treatments incorporated. In only one of these experiments did phosphate give a significant increase in the final yield, but there were usually increases in the first two picks confirming that phosphate makes the crop earlier. There was no reaction between different rates of phosphate application and nitrogen. In times of application, early sowing was not significantly better than later. There was no difference in yields between applying the phosphate in the seed hole or at two depths below the seed.

Unlike the results of the previous season, stopping watering at the end of December gave 15% loss of yield for Sakel and 25% for X 1730 at the G.R.F.; yields were high in the experiment. In the northern Gezira there was no loss in yield.

A sowing date and spacing experiment was carried out using a blackarm resistant variety. Differences were not large and difficult to interpret and this experiment will have to be continued for several seasons.

Large differences in lubia yields were obtained in 1951/52 by the use of insecticides in the soil. Cotton on this land in 1953/54 yielded roughly in proportion to the lubia yields.

Cotton Varieties

BAR. 1730L.1, also known as XL.1, is the only blackarm resistant long staple cotton which is grown commercially in the Sudan. It contains only the gene B_2 which confers fair resistance to b'ackarm but is not sufficient in the event of a severe attack. A large number of variety trials have shown XL.1 to outyield X1730A, from which it was derived, in the central and southern Gezira, where there is often some blackarm. In the north where blackarm is rarer, X1730A slightly outyields XL.1; these cottons are not grown commercially in the north, but it indicates the slight superiority of X1730A in the absence of blackarm, XL. 1 is grown on the Government-run White Nile Alternative Livelihood Schemes and in many private Schemes and also in parts of the Gash Delta. Only a small amount is grown in the Gezira Scheme as the Board is not satisfied with its yield or grade. Large scale replicated trials have not been made and therefore no sound argument can be made to refute the data from the variety trials; in the Gash, where again no replicated trials have been made XL.1 has strikingly outyielded X1730A and blackarm is normally less there than in the central and southern Gezira.

The poorer commercial grading of XL.1 cannot be said to be unreliable on the grounds of the absence of replicated trials. Nevertheless numerous spinning tests from variety trial samples have shown X1730A and XL.1 to be of the same quality. These figures were shown to Dr. Kerr, the eminent American cotton breeder, and he agreed. Since, however XL.1 is not highly resistant to blackarm, it is proposed to maintain it only at Block level in the Gezira.

BAR. 4/16 and 5/6 which contain B_2 and B_3 were intended to replace XL.1 but their performance in the testing plot indicates that their yielding capacity compared with X1730A is low. This is their first test for yielding capacity and no conclusions can be drawn from it. No blackarm was present in this plot but any blackarm resistant replacement for X1730A must yield as well as it in the absence of blackarm, at least in an area where the disease is not bad in most years. It is hoped that the two stages of the panmixis plot will produce higher levels of yielding capacity nearer or possibly equal to that of X1730A. Since variability within BAR. 4 16 and 5/6 is low such hopes may not be realised. An intensive crossing programme between BLR. 14/25 and BAR. 4/16 and 5/6 will therefore be undertaken.

Domain Sakel is grown only in the northern Gezira and is susceptible to blackarm and, unlike X1730A, it is also susceptible to leaf curl. The BLR series of strains (blackarm and leaf curl resistant sakel) have the genes B_2 and B_3 and are highly resistant to blackarm. Selection for resistance to leaf curl has not, however, been successful as the degree of resistance obtained is only slight.

In 1952/53, BLR. 14 25 was sown early in the Gash, which practice favours the development of leaf curl, and a heavy infestation occurred. Again in 1953/54, when leaf curl was severe in the northern Gezira variety trial, Domain Sakel significantly outyielded all the BLR varieties which got the disease badly

The introduction of suitable hairiness for jassid resistance into long-staple cottons progresses, but complications have appeared. The H_1 gene which was originally introduced from Ferguson turned out to be linked with a chlorotic gene and this linkage could not be broken in the pure Ferguson. By using BLJR 14 29 (B_2 B_3 H_1 without the chlorotic gene) as the recurrent backcross parent it is hoped to obtain the gene complex for hair intensity from Ferguson without the chlorotic gene.

Breeding for bollworm resistance has produced some preliminary results that are striking.

Other Work in the Gezira.

Weed Control

Ploughing with a shugadisc for control of seid grass gave better results than previous implements. Experimental watering of fallows in the dry season (January) undid the effect of ploughing for seid control (p. 000). A very heavy dose of C.M.U. controlled seid on fallow during the rains. Trials by the Gezira Board with weed killers for fallow weeds have not revealed a satisfactory chemical ; it appears that weeds are more numerous in the Gezira than at the G.R.F. where the initial experiments which led to the Gezira Board trials were carried out.

8 years observations on the rotation fallow weeding trials in which a proportion of all fallows are weeded have not shown any striking effects either in the total weed population nor in the relative numbers of different species.

Water weeds in canals were successfully controlled by an initial dose of copper sulphate followed by continuous application of the chemical. The quantity used was too great to be economic but this is the first time that chemical control has been achieved on a large scale.

Various Crops

The yields of lubia (*Dolichos*) fodder were extremely high in 1953 54 after several poor or very bad seasons. The reason is unknown ; cockchafer grubs, which appear to have been responsible for poor stands in other years, were little in evidence but this is unlikely to be a major cause of the exceptional growth.

Experiments with mixtures of *Clitoria ternatea* with dura and lubia show this to be a promising husbandry method

Amongst miscellaneous crops tried on the Gezira clay and on river silt, rice was again a failure but eleusine did well on river silt though not on clay. Yields of groundnuts in a variety trial in the north were poor. Safflower yielded well at the G.R.F. but did not give a significant response to nitrogen although it followed a dura crop. Considerable work was done on fodders as such

Experiments with seed dressings have led to the recommendation that groundnuts should be treated with a fungicide such as Thiram and that dura seed should be treated with a mixture of Thiram and BHC which seems to protect it from cockchafer grubs. With lubia, on the other hand, BHC treatment of the seed does not protect the plant from the grubs, although BHC soil treatment does so.

Soil Research

The gypsum block method of estimating soil moistures was tried for the first time and some interesting data obtained on the levels from which cotton plants were drawing water and, presumably, nutrients.

A new titration method for cation exchange capacity was evolved to avoid the difficulties caused by the solubility of calcium carbonate in the displacing reagents used in the old leaching method

Examination of patches of good and bad cotton showed that the bad soil was more permeable than the good soil. There were no large differences in nitrates, organic nitrogen or phosphates. The water soluble sodium was less and calcium and magnesium more in the bad soil than in the good soil.

The soil survey team completed the survey of the new Managil extension of the Gezira Scheme.

The yield during the past 6 seasons have been as follows in k.p.f.

	1948/49	49/50	50/51	51/52	52/53	53/54
Zeidab (Irrigated)	3.60	3.78	4.00	3.18	3.78	3.78
Kordofan (rain grown) ...	0.98	0.84	0.81	1:39	1.29	1.29
Equatoria „ „ ...	1.13	1.20	1.46	1.11	0.59	1.16

In south west Equatoria, where most of the Equatoria cotton is grown, sowing was done mainly near the optimum date and the standard of cultivation improved. Pests were not severe, except for pink bollworm locally, but the dry season was more severe than usual and crop was lost through the reluctance of the cultivators to pick all the low grade cotton because of the low price and the social and hunting activities which are customary towards the end of the dry season.

One factor contributing to poor quality of lint is the practice of leaving the cotton on the plants until the eve of the arrival of the buying team ; this exposes it to drying and staining by stainer bugs and smoke. The quality this season was nevertheless good.

Cotton growing was stopped in the dryer area of south west Equatoria — a reduction of 5000 feddans.

Rains were good in the Nuba Mountains ; this resulted in lower lying areas being flooded and in difficulty in weeding. Cotton on higher ground however did very well, pests were not particularly severe and a good overall yield was obtained.

Cotton Varieties

The BAR. 7/8 series showed themselves superior in yield to other varieties in three out of four trials in the Nuba Mountains, at Tozi and at Yambio. This variety has a high ginning out turn but low quality lint

Several American cottons were tried in the Gezira to discover a short staple variety suited for irrigation in the area, in case this should be required in the future. In the variety trials Punjab 268 F (a variety which has been developed for irrigation) did very well but not so well in the Board's observation plots. It should be mentioned that the seed used in the variety trials was probably of a somewhat superior strain to that of the observation plots P. 268 F also did well on rain at Tozi.

Work at Yambio Experimental Farm

This is included under American cotton for convenience since most of the comments here refer to this crop.

In the Catena Fertility Trial some plots were in their fifth year of cultivation. All crops in the fourth and fifth years of continued cultivation grew poorly and gave very poor yields, except for cotton which gave a surprisingly high yield considering the poor growth of the plants.

The Continuous Cultivation Methods Trial is now in its second year. In 1952/53 only the treatments with manuring gave a significant increase in cotton yields over the control but in 1953/54 a light grass mulch did so as well, although the yield of the control was higher than in 1952/53. The effect of continuous cultivation on the control plots will not appear till the third year at the earliest.

Land cleared in March, and kept clean till cotton was sown in June. gave higher yields than land which was cleared 17 days before sowing, Similar treatments for July-sown cotton showed an opposite trend but the differences were small and July-sown yields were much poorer than June-sown, as was expected.

Cotton responded to nitrogen fertilizer and highly to phosphate though the latter result is open to doubt

Seed treatments against blackarm gave no results but hardly any blackarm was present.

A replicated experiment confirmed previous work in showing that fair yields of both crops can be obtained when cotton is sown in June into April-sown beans. This practice would increase the protein diet of the Azande with the minimum of trouble but at the expense of some cotton.

Work at Tozi

It has always been considered that large scale production of cotton in the sparsely inhabited central rainlands, where water is scarce, would depend on mechanisation. Cotton has been successfully sown and weeded mechanically at Tozi and chemical defoliation has been achieved, but this has to be done early, before the humidity drops with the arrival of the north wind and this involves a considerable loss of crop. (p. 000). Most labour in the production of cotton is required for harvesting. There is a cotton picking machine at Tozi which has not yet been tried owing to the departure of the agricultural engineer ; it is felt that such a machine could not be used unless an expert mechanic were available to look after it.

The best yields of BAR. 7/8.1 cotton in experimental plots were good (over 3 k.p.f.) but not nearly so good in fields ; many of these had to be sown too late to get the best yield.

The optimum plant population for mechanically sown cotton would appear to be 15 - 20,000 plants per feddan. At Kadugli, with somewhat higher rainfall, a spacing of 9 x 45 cm. with 3 - 4 plants per hole was found to give the best yield ; this is a plant population of 30 - 40,000 per feddan.

Tozi Research Farm

Tozi's second season had considerably lower rainfall than the previous season. May to July rains were greater but August and September rains much less than in 1952. The arrival of the dry north wind occurred at the same time in both seasons but the winter at Tozi in 1953 54 was cooler than the previous one.

Most crops responded to nitrogenous fertilizer but the responses were on the whole smaller than in the year before. Responses to phosphate occurred less frequently and potash not infrequently decreased yields.

Most work is being done on sorghum, sesame, groundnuts and cotton. The limiting factors in yields of groundnuts this season was the difficulty of achieving a high enough population owing partly to the planter and partly to seed bed losses, and sowing date Plant population was also the major factor limiting sorghum yields and here seed bed losses were the cause. The effect of different preceding crops on yield of sorghum was observed in 1953

Yields of experimental plots were high — up to 2700 r.p.f. for sorghum, 1230 r.p.f. kernels for groundnuts and 1385 for sesame. These yields were much higher than those obtained in bulk plantings.

The main object of sorghum breeding at Tozi is to produce a combine variety for local conditions. Wad Akr has been purified and is now very level but its stem is not strong enough and extrusion of the head rather inadequate. A classification has been made of sorghum varieties. and of groundnuts. Two years experience indicates that sesame varieties are closely adapted to the rainfall of their place of origin. The object of sesame breeding is to introduce indehiscence and shorter nodes into high yielding local varieties which are resistant to marad el dam disease.

A soil and vegetation survey in the Tozi region has enabled a classification of plant communities to be made with the object of distinguishing land suitable for agricultural development.

Various legumes and prostrate perennial grasses are being tried for improvement of fodder.

Diseases and pests were not serious at Tozi apart from those causing pre or post-emergence seedbed losses. Marad el dam disease which can cause severe losses to sesame in Kordofan was widespread but not severe ; it appears that this disease is localised in patches on the plant and that these spread only during rain. Thrips were fairly bad on some groundnut plots and the swarming grasshopper, *Aiolopus*, appeared on a small scale and severely damaged one field of sorghum.

The causes of seedbed losses in groundnuts and sorghum seem likely to be insects rather than fungi since much better results were obtained with insecticidal than with fungicidal treatments.

The thrips which attacks groundnuts at Tozi behaves very differently to that which attacks rain grown cotton in Gedaref District or irrigated cotton in the Gezira. In the latter cases, the insect breeds on weeds and moves to the cotton when the weeds dry up. At Tozi the thrips seems to treat the groundnuts the way it treats the weeds in the other areas, and does not appear to move much from one plant to another.

Central Rainlands, Miscellaneous

An experiment designed to control *Striga* in Kordofan indicated that strains of this parasitic plant have been evolved which are adapted to sorghum or *Pennisetum* but not to both.

Overcropped sandy soil in Kordofan was shown to have much less nitrogen, a lower pH and less exchangeable calcium than land which had been "resting" under gum trees.

AGRONOMY AND PLANT PHYSIOLOGY SECTION.

I. Introduction.

By H. Ferguson

A total of 74 field experiments were carried out at the Gezira Research Farm and included 43 statistically designed experiments, 20 observation plots and 11 small plot, or pot experiments. The section's own experiments consisted of 19 long term and 15 short term full experiments, 16 observation plots and 11 small experiments. The remaining experiments were carried out in co-operation with, or on behalf of other sections. Many of the observation plots were exploratory trials the main value of which is to indicate the likeliest treatments to include in proper experiments. Their results are of little value for any other purpose. The residual effects of a number of treatments on weed and crop growth were observed.

Work on cotton was again the most important and accounted for 33 out of the 43 full experiments. The Entomological Section increased their programme of field experiments in 1952 53 and these accounted for most of the "co-operation" experiments. Much information on new crops, particularly *Clitoria ternatea* had accumulated in previous seasons, and a number of statistically designed experiments were started in 1953 54 to amplify this. These have the dual functions of testing the crops themselves and their effects in the rotation.

Work on experimental records was concentrated on the tabulation and reproduction of summarised results. As a great deal of the ground work connected with this had already been completed a good deal of progress has been made. The section continued its co-operation with the Sudan Gezira Board and Alternative Livelihood Schemes in their experiments, but practically nothing was done outside the Gezira.

The report is arranged as follows :—

I	Introduction.
II	Cotton and Associated Crops.
III	Crops Other than Cotton.

Appendices to parts II and III are available and contain detailed results.

Characteristics of the 1953/54 Season

The rainfall in 1953 54 was slightly below average, but that from 1 July to 15 August was slightly above average. At the Gezira Research Farm there were very heavy rains just before cotton sowing but the rainfall after sowing was well below average. This lower late rainfall was associated with the earlier onset of drier and cooler weather. The period from November till January was exceptionally cold.

Meteorological averages for the current and recent seasons are given in tables 1 to 4.

Table 1.

Monthly Average Rainfall at the G.R.F. (mm.)

Month	1949	1950	1951	1952	1953	Average 1921-50
April	—	9.4	—	—	3.0	3
May	50.0	5.4	14.0	19.0	45.4	15
June	36.7	24.4	11.8	39.8	40.7	33
July	48.1	149.6	29.7	75.7	84.9	130
August	47.4	101.4	125.1	173.3	158.4	129
September	57.2	83.7	37.4	65.0	28.9	55
October	8.0	42.6	19.5	9.3	15.1	15
November	—	—	—	1.0	—	1
Total	247.4	416.5	237.5	383.1	376.4	381
July 1 to Aug. 15 ...	68.3	180.5	48.7	169.8	228.8	215.0 (Average 1919-42)

Table 2.

Evaporation (Piche) at G.R.F. (mm.)

Month	1949	1950	1951	1952	1953	Average 1919-42
April	23.4	21.5	22.1	21.9	20.2	23.0
May	19.1	21.2	17.9	22.7	16.8	20.3
June	19.2	19.5	19.4	20.0	15.9	18.6
July	15.9	8.6	14.8	16.0	8.7	11.7
August	9.5	5.3	10.3	5.5	5.3	7.1
September	9.4	6.7	8.2	7.1	7.2	8.3
October	12.0	10.7	10.6	11.5	12.5	11.9
November	15.3	13.5	13.9	13.7	15.3	14.9
December	12.9	12.4	11.4	14.3	13.3	14.4
	1950	1951	1952	1953	1954	
January	15.1	13.3	13.8	15.3	16.0	15.3
February	17.0	15.9	16.5	16.2	19.6	17.9
March	21.4	20.7	20.4	20.5	21.8	21.2
Total for Year ...	190.2	169.3	179.3	184.7	172.6	184.6
Total till end Nov. ...	123.8	107.0	117.2	118.4	101.9	115.8

Table 3.

Average Maximum Temperature at the G.R.F. (°C).

Month	1949	1950	1951	1952	1953	Average 1919-42
April	40.5	41.1	40.1	40.8	39.3	41.1
May	40.6	41.7	40.7	42.0	41.0	41.0
June	39.7	39.9	40.3	39.5	38.7	39.7
July	37.7	34.6	37.2	37.2	33.4	35.6
August	35.8	32.1	35.3	31.7	31.9	33.5
September	36.0	34.6	35.1	34.5	34.7	35.8
October	38.6	37.8	38.1	37.8	37.6	38.5
November	36.7	36.5	36.1	36.9	36.1	36.8
December	31.5	34.4	30.4	35.9	32.3	34.5
	1950	1951	1952	1953	1954	
January	34.3	34.6	33.9	35.8	34.8	33.9
February	35.0	34.8	36.4	36.5	38.3	35.4
March	38.5	38.6	37.7	39.0	39.9	38.4

Table 4.

Average Minimum Temperatures at the G.R.F. (°C).

Month	1949	1950	1951	1952	1953	Average 1919-42
April	20.0	22.5	17.0	20.3	20.5	20.9
May	23.9	23.9	24.6	23.9	25.0	23.7
June	24.0	25.3	23.6	25.1	23.0	24.4
July	23.9	21.7	23.6	23.4	22.0	22.5
August	22.1	21.7	22.4	21.4	21.7	22.0
September	21.5	21.3	21.9	21.2	21.3	22.0
October	21.7	21.2	22.3	20.6	20.7	21.9
November	17.7	18.3	16.9	17.4	17.5	18.2
December	11.8	14.5	10.1	16.8	11.0	15.2
	1950	1951	1952	1953	1954	
January	13.9	13.5	14.4	15.4	13.0	14.2
February	14.5	12.9	15.4	16.6	17.3	15.1
March	18.4	17.7	17.1	17.7	17.7	17.7

Though some damage was done to early-sown crops by flooding, the weather was favourable for dura and other summer crops and good yields were obtained. The drier weather in October and the cold winter did not favour the increase of pests, and unlike the two previous seasons, cotton and lubia were relatively pest free. The yields of cotton at the Research Farm were extremely good, and those of lubia were exceptional throughout the Gezira. The very cold period at the beginning of winter had certain adverse effects on cotton and some fodder crops, but suited winter crops, such as wheat and safflower, which gave exceptionally good yields in 1953/54.

II. Cotton and Associated Crops.

By H. Ferguson and S. Gray.

Establishment Growth Yield and Grade of 1953/54 Crop.

Gezira Research Farm

The average yield of cotton at the Gezira Research Farm was 5.57 kantars per feddan = 126% of the average (35 36 - 44/45) of the Standard Agronomy area. Table 5 gives the comparison with recent seasons.

Table 5.
G.R.F. Cotton Yields.
(k.p.f.)

Season	Sakel	X1730A	Mixed	American	Av. all varieties
Av. 1935/36—44/45	3.89	4.93	—	—	(4.408)*(100)
1946/47 V. Good Season ...	3.70	6.32	4.01	—	5.39 (122)
1947/48 F. Poor Season ...	2.58	4.31	4.25	—	3.93 (89)
1948/49 F. Poor Season ...	2.91	4.44	3.24	—	4.03 (91)
1949/50 F. Good Season ...	3.37	5.28	3.12	—	4.63 (105)
1950/51 Excellent Season ...	5.74	7.75	5.23	5.10	6.95 (158)
1951/52 V.V. Bad Season ...	2.23	2.53	3.00	—	2.50 (57)
1952/53 F. Poor Season ...	2.62	4.50	3.35	—	3.95 (89)
1953/54 V. Good Season ...	5.37	6.42	3.48	—	5.57 (126)

*For Standard Agronomy Area.

Though the early growth of cotton in 1953 was less lush and vigorous than in some seasons it set a heavy crop of bolls which it was able to retain, and produced not only a high average yield, but even record yields for some experiments. Pests and diseases did very little damage at the Research Farm, and this must have contributed largely to the good yields. The quality of the crop as judged from graded samples was average. The very cold spell from late November till nearly the end of December had an adverse effect on both yield and quality, and the bad boll opening which occurred appears to have been associated with this.

Throughout this report the following abbreviations are used :—
k.p.f. = kantars (315 rotls) per feddan (for seed cotton only)
r.p.f. = rotls per feddan (1 rotl = .99 lbs. : 1 feddans = 1.038 acres).
C = Cotton ; D = Dura ; L = Lubia ; F = Fallow.
IN (or P or K) — 40 rotls N (or P_2O_5 or K_2O) per feddan.
SE = Standard Error ; C of V = Coefficient of Variation.
+ = Significant at P = 0.05 ; ++ at P = .01 and +++ at P = .001.
Sig. Diff. = Significant Difference (at P = 0.05 unless otherwise stated).

The rainfall factors indicated a good yield at the Research Farm. Though the previous season's rains were about average, the presowing rains were well above average. Estimates based on the rainfall regression equation for the Centre Group of the Gezira indicated yields nearly as good as those of 1950/51. Conditions for sowing and establishment were exceptionally favourable. Very heavy rains fell during the first week of August but at the Research Farm rains were light during and after sowing time though conditions were otherwise cool and humid. Weed growth in the crop was exceptionally light.

Late rains (September and October) were below average and there was an early and definite onset of winter conditions characterised by low humidity and cool nights. These conditions caused early cessation of vegetative growth and early and heavy flowering which resulted in the relatively small plants and heavy bolling characteristic of the season.

The main feature of the winter weather was an exceptionally cold spell lasting from 24 November till 24 December. This further checked vegetative growth and prevented the setting of new crop. It delayed boll opening and was undoubtedly reponsible for the bad opening associated with scorch which occurred. Cold sunny weather was also responsible for the development of anthocyanin pigments in all parts of the plant, giving the whole crop a red appearance. Warmer weather in January and hot spells in February came too late and probably did the crop more harm than good. Because of the early and heavy set of bolls picking would have been early, but was delayed by the cold spell. Partly because of this, and partly because of the hot spell, exceptionally heavy picks occurred in February. As was to be expected late picks were light.

The effect of the weather on pests and diseases was probably as important, if not more so, as its direct effect on the crop. The relatively dry post-sowing conditions were unfavourable to blackarm and most pests, and an incipient attack of whitefly which occurred in September was probably stopped by the onset of dry cool conditions. Whitefly and American bollworm did some damage in sheltered lush cotton. Leaf curl though severe in some parts of the Gezira was light at the Research Farm.

As pests and diseases were not a limiting factor, effective experimental treatments gave good responses in 1953 54. The responses to nitrogenous fertilizers, and to treatments affecting the nitrate status of the soil (*e.g.* fallow hoeing and rotation), were particularly large in some plots. In unmanured plots N deficiency symptoms (yellowing and reddening) appeared rather suddenly in October – due probably both to the heavy bud production and to the onset of cool weather. 1953 54 was an excellent season for Sakel cotton, which produced record yields in some experiments ; lack of pests and heavy early flowering both favoured this variety.

It is noteworthy that in all three-course rotations (main crop and experimental), and in the C-F-F-C serial of the eight-course rotation, the 1953 54 crop was on the same plots which produced bumper yields in 1950 51. These might be expected to have an adverse residual effect, and plots not on a three-course cycle have generally given relatively better yields (*e.g.* two course rotations and unmanured areas of the D-L-F-C phase.).

However this effect is only partly borne out in the Combined Rotations Experiment where there is a strict comparison.

Comparing Gezira Observation Plots, yields were best at the Research Farm, second best at Hag Abdulla, and poorest at Turabi. This corresponds with the pattern of yields in the Gezira as a whole, and is nearer what is normally expected than the results of recent seasons for these plots.

The 1953/54 Commercial Crop

The final Gezira yield was 4.69 k.p.f. In view of the favourable rainfall factors and relative lightness of pest damage this was a disappointing yield. The yield forecast estimated by the 40 block regression equation from the two rainfall factors was 5.02 k.p.f. Allowing for probable increases from manuring, spraying and fallow hoeing, at least 6.0 k.p.f. might have been expected.

Pests were locally more severe in the Gezira than at the Research Farm. American bollworm caused considerable shedding of buds in in the southern Gezira and whitefly were heavy enough to cause appreciable damage in some places in the south and west. Cotton aphis did some damage on some areas. Jassids were potentially serious, especially in the north, and there was severe damage on the few unsprayed numbers. In the Sakel area in the northern Gezira leaf curl was much more severe and much earlier than for very many years. This attack must have reduced the yield in the north by at least 1 k.p.f. Sakel generally gave a relatively poor yield, though some of the southern Sakel blocks and those of the northern extension did well.

The cold spell in November and December had the same adverse effects on the crop throughout the Gezira as at the Research Farm. The worst effects occurred in the north where the weather was coldest and there bad boll opening occurred to such an extent as to cause anxiety. Two types of bad opening were apparent, small underdeveloped bolls which hardly opened at all and larger bolls with scorched soft patches on the most exposed part of the boll showing premature cracking. The former occur to some extent every season, the latter occurred extensively in 1948/49 which also had a spell of very cold weather, and in other similar seasons. Leaf curl may have been partly responsible for underdeveloped bolls, as low weight of seed cotton per boll is associated with heavy leaf curl infection.

Grades throughout the Gezira were below average, but were much better than in the previous year.

Experimental Results.

Yields in all experiments at the Gezira Research Farm were well above average in 1953/54. Record yields were obtained in the Combined Rotations Experiment and in the Two Course Rotations Demonstration. In the Continuous Cotton plot the yield of untreated continuous cotton was the highest since 1942 43 and fourth highest since the experiment began. These record yields in some of the oldest experiments reflect the generally good performance of Sakel in the current season at the G.R.F. In the other long term experiments yields were good but not as high as those of 1950 51. Large responses to nitrogenous manuring, to fallow hoeing and to lubia in the rotation were recorded in most, but not all, experiments involving these factors.

The short term experiments in 1953 54 included repeats of the Watering and Sowing Date Experiment, an important experiment on sowing date and spacing, and a number of experiments on phosphate manuring. These are all reported below.

Detailed results of both long term and short term experiments are available in Appendix I to this part of the report. Comments on the 1953 54 results of some of these experiments are given below.

Continuous Cotton Demonstration.

The yield of continuous (untreated) cotton in this experiment was 3.26 k.p.f. in 1953/54. This was the best yield for eleven years and the fourth largest the plot has produced. It was 76% above its 35 years average.

Only residual effects were measured in small scale experiments on this plot in 1953 54. The effect of one fallow with and without 40 rotls of N per feddan was tested out in 1952/53. It is interesting to note that the direct response was greater to the fallow, but the residual response greater to the nitrogen. This is shown in table 6.

Table 6.

Direct and Residual Response to Fallow and Nitrogen in Continuous Cotton.

Treatment	Yields k.p.f.					
	Direct 1952/53			Residual 1953/54		
	ON	IN	Av.	ON	IN	Av.
C C C C	1.15	1.35	1.24	4.07	4.51	4.29
C C F C	1.41	1.41	1.41	3.84	4.43	4.14
Average	1.28	1.38	1.33	3.96	4.47	4.22

F.C. was significantly (P = .05) better than C C in 1952/53.

IN was significantly (P = .05) better than ON in 1953/54.

Considering the gross two years' yields it would appear that neither the N nor the fallow have had any significant effect.

Two Course Rotation Demonstrations

In these plots the yield of Sakel was the highest ever in all three rotations, though the very first yield in the C-D rotation (before treatments became effective) was higher. These yields were L-C : 7.09, F-C : 5.57, and D-C : 3.54 k.p.f., their relation to each other being very similar to that of other seasons. X1730A yields were the highest ever in the C-D and C-F rotations, but not in the C-L rotation. They were all slightly lower than the Sakel yields.

Dura gave a good yield and lubia a very good yield in the dura and lubia phases of these rotations.

Three Course Rotations Experiment

Yields of cotton in this experiment were good but not exceptional. The yields are given in table 7.

Table 7.

Three Course Rotations Experiment.

Rotation.	Yield (k.p.f.)
F-F-C	4.79
D-F-C	4.34
D-D-C	2.58
L-F-C	6.60
D-L-C	6.32
Significance	+++
S.E. Treat. Mean	±0.307
Sig. Diff. (P. = .05)	0.95
C. of V.	12.5%

In recent years the above order of magnitude has become the expected one, but the gap between rotations containing lubia and those without is much larger than usual.

Dura yields in this rotation were lower than last year. Relative to other yields the two dura phases in C-D-D were better than usual. Lubia after cotton was good but after dura rather poor.

Combined Rotations Experiment

The only rotation which did not produce a record yield in 1953/1954 was, F-L/D-C. The other three course rotations, L/D-F-C and, F-F-C were relatively as usual. The two course rotations, C-D/L and C-F which usually fall second and third after continuous cotton were third and fifth respectively in order of magnitude. Table 8 gives a comparison of the 1953/54 record yields with the two previous best seasons and with rotational means for 1936/37—52/53 (*i.e.* the period after rotations were fully established).

Table 8.

Combined Rotations Experiment.

Rotation	Yield k.p.f.			
	1953/54	1950/51	1944/45	Mean 1936/37—51/52
A Continuous C ...	3.23 (52)	1.82 (41)	2.28 (44)	1.41 (46)
M F-C	5.86 (93)	4.22 (94)	4.42 (86)	2.56 (84)
G F-F-C	7.32 (117)	4.79 (107)	5.94 (116)	3.33 (109)
K F-F-F-C	7.87 (126)	6.56 (147)	6.62 (129)	3.93 (128)
E L/D-C	4.68 (75)	4.19 (94)	4.32 (84)	2.62 (86)
F L/D-F-C	7.22 (115)	5.40 (121)	5.39 (105)	3.54 (116)
J L/D-F-F-C	8.91 (142)	6.75 (151)	6.74 (131)	4.01 (131)
H F-L/D-C	4.44 (71)	4.11 (92)	4.73 (92)	2.80 (92)
O F-L/D-F-C	7.68 (123)	5.38 (120)	5.97 (116)	3.55 (116)
P F-F-L/D-C	5.53 (88)	4.47 (100)	4.98 (97)	2.84 (93)
Season Mean	6.27 (100)	4.47 (100)	5.14 (100)	3.06 (100)
Significance	+++			
S.E. (Treat.Mean) ...	±0.55			
Sig. Diff.	1.57			
C. of V.	9.76%			

The difference in cotton yield between the lubia and dura halves of the rotations containing these crops was relatively and absolutely much larger that in other seasons in rotations H and J, and slightly larger in E (*i.e.* in the rotations where cotton follows dura or lubia in the previous year). Undoubtedly this is in part the effect of the heavy yields of dura in 1952 53 and in turn explains the relatively poor performance of rotations H and P in 1953 54.

Where dura followed a fallow (rotations H, O and P) its yields were higher than last year ; where it followed cotton (E, F and J) they were lower. They fell in the expected order, and those after fallow (av. 3170 r.p.f. fresh heads) were more than twice those after cotton (av. 1295 r.p.f.).

Lubia yields were higher than those of the previous seasons and fell in the same order.

Old Observation Plot (H. 57)

The yield of plot 57 was 9.22 k.p.f. and was the 4th highest yield ever recorded. This yield was consistent with the general performance of Sakel at the Research Farm, and was 196% of the average Gezira yield for the original 40 blocks. This relationship is similar to that of plot 57's more normal seasons, but in view of increased manuring etc. in the Gezira it is higher than would now be expected.

Comparing the plot 57 observations with those of recent years the almost complete absence of pests and diseases is one of the most important features of the season. There was no blackarm, leaf curl was practically absent till the end of the season, whitefly, jassids and thrips were very light, and grasshoppers though they did some damage early in the season had little effect on the crop. Pink bollworm was much less than last year and caused only very slight loss of bolls at the end of the season. The absence of pests and diseases is reflected in the small amount of shedding and in the high weight of seed cotton per boll. A comparison of these observations for recent years is given in table 9.

Table 9.

Plot 57. Fruit Shedding and Boll Weight.

Season	% of Fruiting Points Shed. Samples at end of			Average weight of Seed Cotton per boll (g.)
	October	November	January	
1948/49	11.59	26.6	38.4	1.43
1949/50	10.06	31.9	48.1	2.08
1950/51	16.4	18.9	28.2	3.11
1951/52	5.0	13.0	41.0	1.81
1952/53	9.6	15.4	45.4	1.34
1953/54	4.4	17.6	25.3	2.49

The very heavy picking in February is illustrated in table 10.

Table 10.

Plot 57. Weight of Seed Cotton and No. of Bolls.

Season	Weight of Seed Cotton (S.C.) and No. of Open Bolls (O.B.) per plant (cumulative) till :—							
	End January		End February		End March		End April	
	S.C. g.	O.B. No.	S.C. g.	O.B. No.	S.C. g.	O.B. No.	S.C. g.	O.B. No.
1948/49 ...	10.6	7.2	14.8	10.6	14.9	10.7	—	—
1949/50 ...	3.0	1.5	17.0	8.0	23.8	11.7	—	—
1950/51 ...	25.5	8.1	66.4	21.1	81.9	26.6	88.7	29.4
1951/52 ...	7.9	3.3	26.6	17.2	28.5	18.6		—
1952/53 ...	17.3	13.3	20.9	16.8	—	—	—	—
1953/54 ...	24.3	8.6	62.0	23.6	72.6	28.1	—	—

The observations recorded indicate a similarity between the the 1953/54 and 1950/51 crops which is borne out by most other observations made.

Table 11.

Comparison between G.O.P. and Commercial Crop Yields k.p.f.

Site.	Variety.	Mean 45/46-50/51	51/52	52/53	53/54
	Domains				
Turabi G.O.P. ...	Sakel	5.16(100)	4.20(100)	6.24(100)	3.00(100)
Turabi Block ...	,,	3.48(67)	2.69(64)	4.37(70)	3.95(132)
Kab el Gidad block	,,	4.16(81)	3.53(84)	5.34(85)	4.07(136)
G.R.F. G.O.P. ...	X1730A	5.50(100)	3.59(100)	2.81(100)	7.60(100)
Barakat Block ...	,,	4.66(85)	2.66(74)	4.57(162)	5.72(75)
Hag Abdulla G.O.P.	X1730A	8.61(100)	4.28(100)	5.05(100)	6.87(100)
Hag Abdulla Block ...	,,	5.56(65)	2.94(69)	4.35(86)	5.15(75)
Abu Guta G.O.P. ...	BAR X1730L.1	5.45(100)*	3.89(100)*	4.71(100)	4.70(100)
Abu Guta Block ...	,,	3.91(72)*	2.42(62)	4.05(86)	3.74(80)

*X1730A during these seasons.

It will be seen that, except for the Turabi G.O.P., the G.O.Ps bear the expected relationship to the commercial crop. The unmanured treatment yields at Turabi were exceptionally low, whereas practically all of the commercial crop was manured.

In common with other plots at the Gezira Research Farm the G.O.P. was practically free from pests and diseases, that at Hag Abdulla suffered from American bollworm, and that at Turabi from leaf curl. These factors were probably the most important affecting the yield of these two plots. Comparative figures for shedding are given in table 12.

Table 12.

Gezira Observation Plots — Shedding at end of November 1953/54.

(Av. Masseys Selected Domains Sakel)

Site	Fruit Point Shed % of Sympodial Nodes	Sample of shed		Buds* Total
		Bollworm	Not Bollworm	
Turabi	35.3	227	74	301
G.R.F....	34.6	204	896	1,100
Hag Abdulla ...	48.5	1,652	768	2,420
Abu Guta	38.7	565	2,146	2,711

*Per 64 sub-plot ridges.

The Hag Abdulla count of bollworm sheds was the highest on record for this early date (end November) for all G.O.Ps ; and nearly three times the previous highest for the Hag Abdulla plot. The shedding from " other causes " was below average, but even so the % shed of fruiting points at the end of November is one of the highest recorded. Of the individual treatments the highest % shed come from the close-spaced manured, second highest from wide-spaced manured and lowest from close-spaced unmanured.

The exceptionally low total sheds (c.f. % shed) recorded at Turabi is probably due to the relative sterility of the plants caused by leaf curl as well as the absence of other physiological factors causing shedding. The percentage of plants infected with leaf curl on Masseys Selected Domains Sakel at the end of November at Turabi was 67.5 against 1.8 at Abu Guta, and nil at Hag Abdulla and the Research Farm. With one exception (Turabi 1946 47, which also gave a poor yield) this was the earliest and highest rate of infection ever recorded in any of the G.O.Ps.

With regard to other pests and diseases an early attack of whitefly was recorded at the three outstations, but died out with the early arrival of cool dry weather. Jassids would have been severe at Turabi if the plot had not been sprayed. At Abu Guta a few plants from both varieties and in all G.O.P. treatments developed a " crazy top " appearance distinct from leaf curl. This is under investigation.

The Research Farm and Hag Abdulla G.O.P. gave mean responses of 5.10 k.p.f. (102%) and 4.71 k.p.f. (110%) respectively to nitrogenous fertilizer in 1953 54. These large increases are considered to be due to the absence of pests and diseases late in the season and possibly to the residual effects of the 1950 51 crop. This large response to manure is associated with marked differences in the basic characters of the plant-height, number of main stem nodes, sympodial branches and sympodial nodes. The differences in some if not all of these characters between manured and unmanured treatments in the Research Farm G.O.P. were the biggest recorded. The differences in secondary characters such as defoliation and fruit shedding were not marked.

With regard to other comparisons in the G.O.P.s, Masseys Selected Domains Sakel gave a significantly poorer yield than X1730L-1 at Abu Guta and than X1730A at Hag Abdulla, and close spacing gave a significantly higher yield than wide spacing at Turabi. None of these differences were large.

Distribution of Ammonium Nitrate Experiment

In the Gezira Scheme ammonium nitrate is applied by hand in lumpy condition whereas at the Research Farm it is broken up, applied uniformly and covered. The purpose of this experiment was to compare the Gezira Board method of application with the more refined methods used at the G.R.F. and with ammonium nitrate prills, which permit of even distribution without any special preparation. In all cases the fertilizer was applied at the time of reridging (about 4 weeks

before sowing), so that there was no loss from prolonged exposure in any method of distribution. In this respect all the methods differed from Gezira practice. Application by seluka (sowing stick) which involves placement and covering was found to be significantly better than other methods of application. Prills gave higher yields than ordinary ammonium nitrate but not significantly. The results are given in table 13.

Table 13.

Distribution of Ammonium Nitrate.

	Treatment.	Yield k.p.f.
1.	No fertilizer	4.80
2.	A/N spread evenly before reridging	7.22
3.	A/N spread in lumps before reridging	7.09
4.	A N applied by seluka after reridging	7.78
5.	A N Prills as (2) above...	7.34
6.	A/N Prills as (4) above...	8.09
	Standard Error (treatment mean)	+0.22
	Coefficient of Variation	6.9%
	Sig. Diff.	0.65

Phosphate Manuring Experiments

Following a study of the results of long and short term phosphate experiments, a number of phosphate experiments were included in the 1953 54 programme of work to elucidate further information on rates, times and methods of application of phosphate. Only one experiment showed a significant increase in total yield from phosphate application, though others generally showed small increases. Analysis of the first two picks showed several significant increases from phosphate, confirming previous experience that phosphate increased earliness. During 1953 54 plant observations were carried out in some treatments of the N.P.K. experiment to clarify the mechanism of this earliness. These indicated that flowering started earlier in phosphate treatments and that the time between flowering and boll opening was less. The opposite was the case in the nitrogen treatments.

Phosphate and Prewatering Experiment

In this experiment 2 P gave a significant increase of .69 k.p.f. in the final yield, 2N gave an increase of 2.97 k.p.f. and prewatering at 1, 3 and 6 weeks before sowing gave an increase of .76 k.p.f. which was significant. There were no significant interactions and thus nothing to indicate that prewatering improves the response to phosphate. However it must be remembered that this plot in common with others was very severely flooded shortly before cotton was sown.

Phosphate and Nitrogen Experiment

No interaction between different rates of nitrogen and different rates of phosphate application were found. The yields for early and total picks for this experiment are given in table 14.

Table 14.

Phosphate and Nitrogen Experiment.

Response to Nitrogen			Response to Phosphate		
Treatment	Yield of Seed Cotton (k.p.f.)		Treatment	Yield of Seed Cotton (k.p.f.)	
	Picks 1 & 2	Total		Picks 1 & 2	Total
0 N	2.00	5.22	0 P ...	1.88	7.52
1 N	2.54	6.78	1 P ...	2.33	7.51
2 N	2.33	8.42	2 P ...	2.28	7.64
3 N	2.15	9.98	3 P ...	2.52	7.75
Significance ...	++	+++		+	N.S.
S.E. (Treat mean) ...	±0.12	±0.13		±0.12	±0.13
C. of V. ...	23.2%	7.4%		23.2%	7.4%
Sig. Diff. ...	0.33	0.36		0.33	

These results demonstrate the slight response in early crop to phosphate and the large response in late crop to nitrogen. The time of arrival of the crop is important in relation to grade so that the value of the response to phosphate is relatively greater than that shown and the value of the response to nitrogen relatively less. Samples from all pickings and all treatments of this experiment were graded and grades weighted by picking weights. The summarised results given in table 15 illustrate well the effect of P and N discussed above.

Table 15.

% Grades Related to N. and P.

Treatment.	% Grade					
	1	2	3	4	5	6
0 P 0 N	—	3.4	—	—	93.1	3.5
P 0 N	—	5.9	3.9	31.0	51.0	8.2
0 P N	—	1.9	1.4	13.0	69.9	13.8
P N	—	4.2	1.6	20.8	51.0	22.4

Method and Rate of Phosphate Application

Though the yield of cotton from 2P was .98 k.p.f. higher than that of OP this did not reach significance and no significant response to any treatment or interaction was obtained in this experiment. This is the only one of the experiments in which nitrogen treatments were not included.

Time of Application of Phosphate

In this experiment 2 P was applied in one dressing at sowing time, two dressings (1 at sowing and 1 before flowering) and four dressings (1 at sowing, 1 during early growth, 1 before flowering and 1 during flowering). The single application at sowing time gave a significant response for the first two picks, but not in final yield.

Miscellaneous Exploratory Trials

It must be emphasised that the sole purpose of these experiments is to indicate possibilities for future full experiments and that no other significance should be attached to their results.

In small exploratory trials there was no indication of marked benefit from very heavy dressings of nitrogen on fertile soil. There was some indication of beneficial effects from split applications of nitrogenous fertilizers. This is being tried in a full experiment in 1954/55.

In exploratory pot experiments with minor elements zinc depressed cotton growth at levels of application which improved rice growth. Better root development and increased total dry matter resulted from applications of soil stabilisers (Krilium and a product RA 2484).

Fallow Hoeing Experiments

Fallow hoeing treatments are included in the Types of Nitrogen Experiment and warrant special discussion because of the exceptional results obtained. The rainfall in 1951 was very low and that of 1952 was just below average so that responses to hoeing the two fallows before cotton in F-F-C rotations were not likely to be high. This in fact was the case in the long term fallow hoeing experiments, but in the Types of Nitrogen Experiment there were responses to hoeing of over 3 k.p.f., as well as more normal responses of under 1 k.p.f. In this experiment a significant interaction between hoeing and time of application of fertiliser was recorded. Unhoed plots with early application of fertilizer gave significantly lower yields than those with later applications. This effect may have been due to the early fertilizer encouraging extra weed growth (which is always heavier after unhoed fallows) before cotton sowing. Unfortunately records are not kept of weed growth at this stage but weeding, which is done if necessary in all treatments at this stage, was prevented by rain and flooding.

The relatively abnormally poor yields of most unhoed fallow treatments in the Types of Nitrogen Experiment were associated with poor cotton stand which was confined to these treatments. There was severe flooding before sowing in this plot and wetter conditions in the hoed treatments were reported to have caused rotting of seed and necessitated heavy resowing. It is probable that the deep cracks associated with weedy fallows permitted greater absorption of flood water and resulted in excessive water-logging at the time of the flood and the early irrigations.

Whatever the explanation of these unusual responses to fallow hoeing they are probably secondary or even spurious effects, and should be treated with extreme caution.

Permanent Fallow Hoeing Experiment

This experiment gave no significant increases from any fallow hoeing treatment.

Influence of Fallow Hoeing on Rotations Experiment

In this experiment the effect of hoeing the fallow immediately before cotton is compared in different rotations. A significance response of 1.30 k.p.f. to hoeing this fallow (1952) was obtained.

There was no residual effect on dura or lubia yields of hoeing the fallow before the 1952/53 cotton crop. This was as expected since 1951 rains had been low and fallow hoeing had had no significant effect on the cotton itself.

On the other comparisons included in this experiment Sakel and X1730A gave practically the same yield ; and L-F-C was significantly better than all other rotations except F (Hoed)-F-C.

Residual Effect of Fallow Treatments

The effect of various treatments on fallow weeds had been under observation continuously for 9 seasons in which the plot concerned was fallow. To complete the winding up of these observations cotton was sown to establish the effect of these treatments on yield. In the direct comparison between hoeing and no hoeing, 9 years continuous hoeing of the fallow gave a significant increase of yield of 3.20 k.p.f.

None of the other comparisons gave significant differences. In one comparison ploughing appeared to have an adverse effect and root observations were carried out. Root development was less in the ploughed treatments, but there was no indication from it of any pan effect.

DECEMBER WATER STOP EXPERIMENT

Averaging all other treatments the loss in yield from stopping water in December was 1.93 k.p.f. (20%) in 1953/54 which was absolutely and relatively greater than in 1952/53. This is understandable in the light of the cold weather in early winter and consequent latening of the crop, whereas the crop in 1952/53 matured exceptionally early.

Both the variety and sowing date had significant effects on the response to early water stop. The full results are shown in table 16.

Table 16.

Effect of December Water Stop.

(k.p.f.)

Date of Water stop	Variety (S. & L. types)	Sowing Date and Treatments						Mean	
		20/7/53 no pre-water		20/8 after 2 pre-waters		20/8 after no pre-water			
		Var.	Av.	Var.	Av.	Var.	Av.	Var.	Av.
31/12/53	BLR. 14/25/	7.25	7.01	7.70	7.65	7.58	7.21	7.51	7.29
	X1730L-1	6.76		7.60		6.84		7.07	
31/3/54	BLR. 14/25/	7.69	7.54	9.67	10.00	9.24	9.80	8.87	9.12
(Normal)	X1730L-1	7.40		10.33		10.37		9.37	
Mean			7.28		8.83		9.80		

In the above the loss in yield from early stopping was 1.36 k.p.f. (15%) for Sakel (BLR. 14 25) against 2.30 k.p.f. (24%) for X1730L.1. It was only .53 k.p.f.(7%) for early sown treatments, but early sowing as a whole gave significantly lower yields than normal sowing. (See also Spacing and Sowing Date Experiment.).

Early stopping of irrigation tends to make bolls mature more quickly and, as the season advances, to open before they are fully developed. Thus poorer grades would be expected from early water stop but, when samples are graded, the opposite appears to be the case as there is a tendency for earlier picks to get higher grades. In this case this result is probably false and this is confirmed by the results of spinning tests which were carried out on composite samples from all pickings of the 1952/53 water stop experiment. These are given in table 17.

Table 17.

Spinning Test Results from 1952/53 Water Stop Experiment.

Treatment		Fibre Tests				Corrected Lea count X Strength product	Yarn appearance
Sowing date	Water-stop	Effective length 32nd	Maturity Rates	Fibre mean	Wt. per Cm. Standard		
15/7 ...	31/12	48	.905	141	156	1,994	Moderate
15/8 ...	31/12	48	.870	133	153	1,706	Very poor
15/7 ...	31/3	49	.865	135	156	1,952	Moderate
15/8 ...	31)3	49	.935	137	147	1,958	Moderate

These results indicate a loss of quality from early water stop associated with normal sowing.

Pest observations were carried out in this plot. Infestation was generally very light but early sowings showed slightly higher whitefly numbers.

In a water stop experiment at Shabasha on the White Nile the December stop gave 4.21 k.p.f. against 6.25 k.p.f. for normal water stop — a loss of 33%. Under practical field conditions there is always a danger that some other adverse factor (*e.g.* delayed sowing or delayed weeding) may greatly increase the loss from early stopping. However it appears from all December water stop results so far obtained that an economic yield can be obtained if no stored water is available for irrigation after 31 December.

Early Water Stop Experiment (*northern Gezira*).

The crop as a whole is earlier in the northern Gezira and previous trials indicated that early stopping had little effect on yield. This has been confirmed in the current experiment the summarised results of which are given in table 18.

Table 18.

Early Water Stop (northern Gezira).

(Domains Sakel k.p.f.).

Date of Water Stop	Yield (other treats. av.)
31.12.53	6.70
31. 1.54	6.96
31. 3.54	6.60
Significance	N.S.
Standard Error (treat mean)	±0.15
C. of V.	9.7%

Differential prewatering and December watering treatments had (unlike those at the Research Farm) no effect on yield.

In the Water Stop Demonstration at Abu Guta with variety X1730L-1 December water stop gave consistently lower yields than January, February and March water stops.

Cotton Sowing Date and Spacing Trial.

The breeding of blackarm resistant varieties has lessened the risk of blackarm from early sowing. From this point of view July sowing is a practical possibility, but the cooler, moist weather of this time of year encourages excessive vegetative growth. This in turn causes excessive bud shedding, either directly because of shading, or be-

cause of the better environment offered for American bollworm and consequent increased attack. These factors tend to reduce both yield and grade. This experiment was designed to find out if wide spacing would counteract these effects of early sowing. In addition to taking yields, both plant and pest observations were made to facilitate the interpretation of the results. Pest infestation was negligible thus allowing the physiological effects of the treatments to express themselves.

The whole experiment was given a dressing of 80 rotls N per feddan to eliminate nutrient deficiency as an interacting factor. The spacings compared in the experiment were normal (80 x 50 cm.), twice normal by two methods (80 x 100 and 160 x 50 cm.), and four times normal (160 x 100 cm.). At 3 plants per plant hole the correspnnding full plant populations are 10,080, 5040 and 2,520 plants per feddan. The lower the population the greater the adverse effect on yield of poor stand. This may be an important factor under farming conditions where stands are sometimes patchy. The full results of the experiment are given in table 19.

Table 19.

Spacing and Sowing Date Experiment — Yields.

(X1730L-1, k.p.f.).

Spacing (cm.)				Sowing dates		Means	
Rows		Plants	...	15/7/53	15/8/53		
80	x	50	... ...	7.75	8.11	7.93	8.00
80	x	100	... ...	8.16	7.99	8.07	
160	x	50	... ...	8.59	8.64	8.62	8.40
160	x	100	... ...	8.58	7.78	8.18	
Mean				8.27	8.13		

The average difference between July and August sowing is not significant. Averaging both sowing dates the 160 x 50 cm. spacing (twice normal) was significantly better than 80 cm. rows. For late sowings (15 August) 100 cm. between plants gave significantly poorer yields than 50 cm. between plants. None of these differences were large and the trial would have to be repeated for several seasons to make sure that they are consistent. They indicate that close spacing is better for the normal, later sowing, and that wide spacing is more beneficial if distances between rows rather than distances between plants are increased.

Even though no increase in yield results from early sowing it has other advantages. As indicated earlier there is likely to be less loss from early water stop, and there is likely to be better grade because of the higher proportion of early picks. It has been argued that wide spacing should also give better grade, because it should encourage the retention of the bottom crop.

A series of plant observations were carried out in the different treatments in this experiment to evaluate differences in plant characters. and in particular to find out how these differences were likely to affect the grade of the cotton from different treatments. For the sake of brevity only the observations made on the closest (50 x 80 cm.) and the widest spacing (100 x 160 cm.) will be considered. As was to be expected, the size and form of the plants differed markedly. Selected plant characters are given in table 20 to illustrate this.

Table 20.

Spacing and Sowing Date — Plant Observations.

(Samples taken January 1954)

Observation	No. per plant (unless otherwise stated)			
	Spacing 50 x 80		Spacing 100 x 160	
	Sown 15.7	Sown 15.8	Sown 15.7	Sown 15.8
(1)				
Main stem:				
Height (cm.)	122	112	133	123
Nodes	33.6	31.2	38.0	37.0
Defolialion	17.4	16.1	18.0	16.6
(2)				
Branch:				
Branches	18.8	17.2	21.5	23.0
Nodes	56.0	54.6	90.2	75.1
Fruits	24.9	24.1	61.5	58.4
Shed Nodes	31.1	21.7	28.7	16.9
Nodes per branch	2.9	2.4	3.5	2.8
% Shed Nodes	56	45	37	23
(3)				
Seed Cotton:				
Wt. of seed cotton per boll (g.) ...	2.54	2.60	2.83	2.87
(4)				
Pests:				
% shed due to bollworms in Nov.	14.3	18.3	17.4	12.5

Notes :—(1) Sample for all treatments taken 5.1.54.

(2) Sample for 15.7. treatments taken on 5.1.54 and for 1.8. treatments on 28.1.54.

(3) Mean for all pickings.

(4) From Entomological Section's observations.

From the above it will be seen that for both spacings early sowing produced plants which were in every respect larger than those of late sowings, but fruit shedding was markedly greater in the early sown crop. Wide spacing produced larger plants than close for comparable sowing dates and in particular produced many more sympodial nodes and fruit. The % shed was much less and boll weight greater in the wide spaced. As there is little difference between the yields of all these treatments it will be seen that these characters compensate for the difference in plant population.

Pest observations made by the Entomological Section indicated the lightness of pest attack. From table 20 it can be seen that there is no real evidence of greater bollworm attack in early sown or close spaced treatments. Whitefly counts were not appreciably different for different treatments. The number of jassids and aphids per plant was greater on the wide spaced treatments, but the number per feddan was less.

The distribution of the crop on the plant was evaluated by picking separately the crop from different zones of random plants from each treatment. The number of bolls and weight of seed cotton per zone are given in tables 21 and 22 respectively and the average weight of seed cotton per boll per zone in table 23.

Table 21.

Boll No. by Zones.

Zone.	Node No.	No. per single plant per treatment				Per ¼ plant*	
		Close		Wide		Wide	
		15.7	15.8	15.7	15.8	15.7	15.8
I	41-45	—	—	2.0	—	0.5	—
H	36-40	1.5	—	7.2	8.5	1.8	2.1
G	31-35	6.8	1.0	15.8	8.5	4.0	2.1
F	26-30	9.0	7.0	19.0	16.0	4.8	4.0
E	21-25	6.8	9.5	14.8	12.2	3.7	3.1
D	16-20	3.3	6.5	14.5	18.8	3.6	4.7
C	11-15	5.0	1.5	14.8	18.0	3.7	4.5
B	6-10	1.0	0.5	2.0	5.8	0.5	1.5
A	1-5	—	—	—	—	—	—
Total ...		33.4	26.0	90.1	87.8	22.6	22.0

*See note on next page.

Table 22.

Weight of Seed Cotton by Zones.

Zone	Node No.	Grams per single plant per treatment				per ¼ plant	
		Close		Wide		Wide	
		15.7	15.8	15.7	15.8	15.7	15 8
I	41-45	—	—	4.6	—	1.2	—
H	36-40	3.6	—	15.8	20.0	4.0	5.0
G	31-35	18.2	2.2	34.2	18.2	8.6	4.5
F	26-30	21.3	27.4	45.1	37.6	11.3	9.4
E	21-25	15.9	21.8	40.1	33.0	10.0	8.2
D	16-20	9.0	15.2	40.7	51.1	10.2	12.8
C	11-15	13.1	3.6	34.6	41.3	8.7	10.3
B	6-10	2.6	0.4	4.1	11.5	1.0	2.9
A	1-5	—	—	—	—	—	—
Total ...		83.7	70.6	219.2	212.7	55.0	53.1

The discrepancies between relative yields per plant (or ¼ plant) given in table 22 and the yields per feddan given in table 19 will be noted. These suggest either an unrecorded interaction between spacing and population or a large sampling error associated with necessarily small size of the sample for these special pickings.

Note:—The data per ¼ plant for the wide spaced treatments are given since four close-spaced plants occupy the same area as one wide-spaced. When considering numbers of bolls etc. per area the ¼ plant data for wide-spaced should be comparable with the single plant for close-spaced.

Table 23.

Weight of Seed Cotton per Boll by Zones

Zone	Node No.	Grams per boll per treatment.			
		Close		Wide	
		15/7	15/8	15/7	15/8
I	41-45	—	—	2.31	—
H	36-40	2.42	—	2.19	2.11
G	31-35	2.08	2.02	2.28	1.80
F	26-30	2.37	2.15	2.43	2.35
E	21-25	2.25	2.27	2.76	2.45
D	16-20	2.61	2.56	2.65	2.66
C	11-15	2.59	2.52	2.37	3.04
B	6-10	2.63	0.70	2.32	3.38
A	1-5	—	—	—	—

It will be seen from table 22, comparing wide ¼ plant with close single plant, that, contrary to expectation, wide spacing has had little effect in increasing the bottom crop from early sown cotton. From observations on shedding (obtained from a completely different series of plants) it will be seen that, though the % of the lower crop shed is less for wide-spaced than for close-spaced, early-sown cotton, it is larger than for close-spaced, late-sown cotton. This comparison is given in table 24.

Table 24

% Fruits Shed by Zones.

(Sampled Jan. 1954)

Zone.	Node No.	% Shed per treatment.			
		Close		Wide	
		15.7	15.8	15.7	15.8
H	36-40	—	—	66.6	33.3
G	30-35	—	—	13.5	10.3
F	26-30	25.7	24.5	15.7	14.0
E	21-25	42.3	28.1	27.8	14.4
D	16-20	52.5	36.9	31.9	23.2
C	11-15	71.4	36.4	47.9	28.6
B	6-10	86.7	45.1	56.6	35.9
A	1-5	—	—	—	—
Average ...		55.7	37.1	45.1	22.8

The importance of time of arrival of the crop in relation to grade has already been stressed. Table 25 gives the weight of seed cotton per plant per picking for the four treatments being compared.

Table 25.

Weight of Seed Cotton per plant for each Picking.

Picking No.	Grams per single plant per treatment.				per ¼ plant	
	Close		Wide		Wide	
	15.7	15.8	15.7	15.8	15.7	15 8
VII	—	—	1.9	9.0	0.5	2.3
VI	5.3	15.2	23.1	53.7	5.8	13.4
V	18.8	29.3	54.9	70.4	13.7	17.6
IV	18.4	22.5	56.5	45.3	14.1	11.3
III	17.1	3.7	38.5	23.7	9.6	5.9
II	13.4	—	26.2	9.5	6.5	2.4
I	10.7	—	18.3	1.1	4.6	0.3
Total	83.7	70.7	219.4	212.7	45.8	53.2

Early sowing has, as expected, increased the early picks. Within this sowing date, wide spacing has given relatively poorer early picks per unit area despite less shedding of bottom crop (see table 24) than in the close-spaced treatment. Field observations indicated that this was due to the poorer environment forcing the close-spaced cotton to open earlier and in a less mature condition. This is confirmed (for the late sowing at least) by the boll weights given in table 23. Samples were graded by S.G.B. graders, and all treatments at the same picking date were usually of the same grade so that the quantity of each grade is closely related to the time of arrival of the crop. Table 26 gives the % of the crop falling into each grade.

Table 26.

Treatment		% of Crop in each Grade.					
Spacing	Sowing Date	1	2	3	4	5	6 and over
Close ...	15.7	—	11	28	—	34	27
,, ...	15.8	—	—	9	—	31	60
Wide ...	15.7	—	—	20	—	25	55
,, ...	15.8	—	—	8	—	20	72

Despite these results the higher weight of seed cotton per boll (sometimes over 4 g.) indicates the probability of better quality from wide-spaced treatments. A full range of samples from this experiment has been submitted for spinning tests.

One final feature bearing on quality should be mentioned. A larger proportion of the crop from the wide spaced treatments gets blown on to the ground, so that under farming conditions this would probably be dirtier.

Weed Control Experiment

In view of the success of a small experiment carried out by the Botany and Plant Pathology Section in 1953 on chemical control of weeds in cotton by pre-emergence weed killers, a full field experiment was carried out in cooperation with this section in 1953/54. Sowing cotton and spraying of the weed killer were carried out on the same day. Different concentrations of one proprietory pentachlorphenol-emulsifier formulation (Kanex) made up in different concentrations of diesel oil were compared with hand weeding at different times.

During 1953 weed growth in the cotton crop was very light as rains caused germination of some seeds before sowing and flooding in early August reduced the germination capacity of others. In October before reridging, the unweeded control had only a 15% weed cover against 3% for hand weeded, and an average of 9% for the Kanex treatments. No ill effects of the chemical or oil were apparent on the crop, but the lower concentrations of Kanex with equal concentrations of diesel oil showed a lower yield which was not quite significant. There was practically no difference in yield between different Kanex rates.

The yields are summarised in table 27.

Table 27.

Pre-Emergence Weed Killer Trial.

Treatment.	Yield k.p.f.
Kanex + diesel oil (av. 3 rates) on 19 August	5.22
Kanex + double amounts oil (av. 3 rates) on 19 Aug.	4.96
Mean of all Kanex treatments	5.09
Hand weeding on 27 August and 10 October	5.74
Hand weeding on 2 September and 10 October	5.64
Hand weeding on 9 September and 10 October	5.40
No hand weeding till 10 October (before reridging)	3.89
S.E. (Treatment Mean)	±0.16
C. of V.	6.9%
Sig. Diff. between Kanex mean and hand weeding treatments	0.35
Sig. Diff. between different hand weeding treatments ...	0.45

It will be seen that the yields following Kanex treatments are slightly but significantly lower than hand weeding, but considerably better than delayed weeding. The experiment should be repeated in other seasons before conclusions are drawn.

Residual Effect of Previous Lubia Crop

In recent years lubia in the standard Gezira rotation (F-F-C-F-D-L-F-C) has suffered severe damage from cockchafer grubs and several experiments on their control have been carried out. Such an experiment was done on the 1951 52 lubia crop when seed and soil applications of BHC formulations greatly improved the growth and yield of lubia. Untreated lubia was somewhere between a lubia crop and an irrigated fallow, whereas the treated lubia produced a full stand and thick cover.

Cotton was grown in its normal place in the rotation (L-F-C) after this experiment and the residual effect on cotton yields is given in table 28.

Table 28.

Residual Effect on Cotton of Lubia Experiment

Treatments in 1951/52.	Lubia yields in 1951/52 r.p.f.	Cotton (X1730A) 1953/54 yields k.p.f.
No treatment	1,883	4.92
Agrocide 2, 5 lbs/feddan	6,731	5.83
Agrocide 2, 10 lbs/feddan	8,137	5.83
Agrocide 2, 20 lbs/feddan	7,645	5.53
Mergamma Seed Dressing 1%	2,997	5.23
Significance	+++	+
S.E. (treat. Means)		+0.21
Sig. Diff.	1,751	0.64
C. of V.	23.8%	8.7%

There will be some doubt as to whether the response in cotton yield is due to the residual effect of the insecticides or of the lubia crop itself. This point will be cleared up in the next few years when the residual effects of *good* lubia with and without insecticides will have been tested.

Minor Trials

Cotton on broad ridges

It was suggested that growing cotton on broad ridges might improve the method of watering and economise irrigation water. An exploratory trial was carried out with ridges, or rather raised plots from 50 to 150 cm. wide at the top and containing from 2 to 5 rows of cotton. The results indicate that a 50 cm. wide ridge carrying two rows of cotton would be practicable and might give improved yields. There was no means of deciding whether this would or would not save water.

Cotton after cracks

In 1952/53 very large cracks were formed in plots where safflower watering had been stopped early. Cotton was grown on this and comparable non-cracked areas in 1953/54. The cracking appeared to have no effect on cotton growth.

Cotton Bast Fibre

Experiments were carried out on the extraction of bast fibre from cotton in connection with the investigations into the utilization of cotton stalks, which are being carried out by the Sudan Gezira Board. Water retting of cotton stalks had been tried some years ago and had produced a poorly retted inferior sample of fibre. The current trials were planned to investigate the factors affecting water retting and to obtain further information of yield of stalks and fibre.

Most bast fibres are most easily retted and produce the best quality fibre if plants are cut at, or shortly after flowering. Obviously this is not possible in the case of cotton, and it seemed likely to be the cause of the poor retting. Accordingly a sample of cotton stalks was cut on 4.3.1954, while still green and growing actively, and retted until the process was complete. This was found by trial to be six weeks. This confirmed previous experiments, where periods of over 6 weeks made little change in the condition of the cotton. The sample of fibre produced was extremely good with practically no bark tissues binding the fibre bundles. After this preliminary trial a comparison of different dates of pulling was carried out on the December Water Stop Experiment, which gave other comparisons of possible importance. These stalks were retted for exactly 6 weeks without considering water temperature and other factors. However as temperatures were rising, later pullings should have more favourable retting conditions. An abstract of the results is given in table 29.

Table 29.

Yields of Stalks and Bast Fibres

(r.p.f.)

Treatment	Pulling Date								
	10.4.54			10.5.54			Means		
	Stalks (S)	Fibre (F)	% F.S.	Stalks (S)	Fibre (F)	% F.S.	Stalks (S)	Fibre (F)	% F.S.
BLR. 14/25 (S)	3850	190	4.9	3382	206	6.1	3616	198	5.5
X1730-L1 (L)	4383	228	5.2	3784	218	5.8	4084	223	5.5
Sown 15/7 ...	4236	232	5.5	3148	212	6.7	3692	222	6.0
Sown 15/8 ...	3997	187	4.7	4018	213	5.3	4008	199	5.0
Water Stop 31/12 ...	3506	197	5.6	3392	199	5.9	3449	198	5.7
Water Stop 31/3 ...	4728	222	4.7	3776	226	6.0	4252	224	5.3
Mean	4117	209	5.1	3583	212	5.9	3850	211	5.5

Apart from the difference between Sakel and X1730 types, which is probably a varietal one, the differences (*e.g.* between early and normal water stop) are probably related to plant growth (see the seed cotton yields of this experiment).

No measure of the effectiveness of retting or the quality of the fibres was possible, and the following is a visual assessment.

Very good	:	Individual sample of Sakel cut 4 March.
Good	:	Sakel pulled on 10 April.
Fairly good	:	1730 pulled on 10 April Sakel pulled 20 April.
Fair	:	Sakel pulled on 30 April.
Poor	:	1730 pulled on 20 and 30 April. Sakel pulled on 10 and 20 May.
Very poor	:	1730 pulled on 10 and 20 May.

There were no visual differences between sowing date or water stop treatments.

The longer, cleaner and finer fibre produced by the Sakel type over the 1730 type is probably in part due to less branching. The higher %of fibre to stem in the case of the late retting is certainly due to the extra unretted tissue noted in these treatments, and as far as water retting is concerned this factor must be kept in mind when comparing different yields of fibre.

The yields in this experiment came from well grown cotton plants which produced an 8 k.p.f. crop, so that they are higher than the average to be expected from Gezira cotton stalks. This would probably be in the region of 150 rotls fibre per feddan. Economic yields of commercial bast fibre crops are about 7 times to 15 times this amount, depending on the crop.

III. Crops Other Than Cotton.

By H. Ferguson.

This section reports the results of experiments and observations on dura and lubia not included in rotation experiments (see part II) and on other crops. Numerical results are available in an unpublished appendix to this section.

Dura

At Turabi, which has the standard Gezira rotation (C-F-D-L-F-C-F-F), and at Abu Guta, with the six course rotation (F-C-D-F-C-L), Observation Plots on variety, manuring and watering were laid down. The results were consistent and confirm those of previous years. Yields at both places fell in the order Wad Fahl, Dwarf White Milo, and Feterita 1931. 40 rotls of nitrogen per feddan gave an average increase of 79% in the six course (C-D) rotation and 22% in the eight course (F-D), but the yields at Turabi (eight course) were 80% higher than at Abu Guta. Watering at 3-weekly and monthly intervals were compared. At both places the three-weekly intervals gave a slightly higher average yield, but the differences were small and inconsistent. In view of the great importance of water economy it has been decided to put these observations to the test in 1954 in a statistically planned experiment.

In the 1953/54 season the effect of sowing clitoria under dura was tested in two experiments, one in the six course rotation and one in the eight course. These were statistically designed experiments and are due to be carried through to the cotton phase of the rotation. Clitoria sown under dura had no significant effect on dura yields in either experiment though it consistently showed a slight reduction. In the six course rotation, where dura yields are normally low, double spacing of dura gave significantly increased yields. See table 30.

Table 30.

Effect on dura yields of spacing and undersowing of Clitoria

(Air dry weights in r.p.f.)

Spacing cm	No Clitoria		Clitoria alternating with dura in the row	
	Heads	Straw	Heads	Straw
80 x 50	871	3,549	614	2,629
80 x 100	1,231	3,886	949	3,026
160 x 50	1,129	3,030	1,150	3,152
S.E. of treat. mean	± 112	± 350	± 112	± 350
Significance	++	N.S.	++	N.S.
Sig. Diff.	325	—	325	—
C. of V.	26.4%	24.6%	26.4%	26.4%

Wheat

The cool winter in 1953 54 favoured the wheat crop, and growth at the Research Farm was excellent.

An observation plot was laid out to see if green manure immediately before wheat and safflower was likely to be more beneficial than a fallow. Yields fell in the following order:—after 1) manured fallow, 2) hoed fallow, 3) cowpea 4) phillipesara. Though only an observation, the yields were consistent throughout the plot. The highest average wheat yield was 1404 rotls seed per feddan, which is good for the Gezira.

Maize

Several small samples of hybrid maize were received in 1953 54 from Mr. Mapplebeck in Cairo. These were sown in the Irrigation Garden on the river silt to give them every chance to show their potentialities. They grew extremely well and gave good but not exceptional yields, some being no better than the variety Mexican June. The best was No. 301 B, which yielded 3750 rotls seed per feddan.

Groundnuts

A variety trial was carried out in the northern Gezira at Turabi. Spanish 1838 (ECR. 702) giving 773 rotls per feddan (undecorticated) was significantly best, with Barberton (ECR 420) and Red Spanish (ECR 677) next. The stand was better than last season though still not satisfactory, and yields were generally low.

At the Research Farm a small trial indicated that continuous or very close sowing of groundnuts was likely to give the highest yield, specially where the stand was uncertain, though this has to be balanced against the high seed rate.

Safflower

A safflower variety trial was carried out at the Research Farm. Yields ranged from 1562 r.p.f. for Nebraska (ECR 1396) down to 1397 r.p.f., but none of the differences were significant. Vegetative growth of all varieties was excellent, but yields though good were not exceptional. Application of 80 rotls nitrogen per feddan gave a non-significant increase in yield of only 13.5%, in safflower following dura in the rotation.

Fodder and Rotation Crops

The observations made in previous years having indicated the most promising fodder and rotation crops and the best methods of growing them, several statistically designed experiments were started in 1953 54 to put these indications to the test. As clitoria promises to be of great value as a rotation crop and satisfactory as a fodder crop these experiments have been concentrated on clitoria.

A fodder farm to maintain a large dairy herd for breeding purposes and to supply Wad Medani with milk has been under consideration for some time. In this farm the prime consideration would be fodder production and not, as in the Gezira area, the rotational effect of the fodder crop. Because of this effect grasses are normally not considered as fodder crops in the Gezira, though with proper management they can be very productive. With the requirements of the fodder farm in view a statistically designed experiment comparing grasses, legumes and mixtures was laid down in 1953/54. This was also based on the observations of previous years.

Lubia

1953/54 was an exceptionally good season for lubia. Pests and diseases were almost entirely absent and growth was so vigorous that the slight attacks of whitefly (*Bemisia gossypiperda*) and Chrysomelid beetle (*Luperodes quaternus*) had no effect. As a result extremely high yields were obtained.

Another result of the good season was that no responses were obtained to ameliorating treatments. Cockchafer grubs were not in evidence so that BHC used as a soil and seed treatment had no effect on yields. Lubia yields were much better than those of any other fodder crop, and in experiments generally produced not less than 10 tons fresh fodder per feddan. 18 tons per feddan were obtained in two cuts from one field.

The residual effect of earlier cockchafer control treatments on cotton yields was shown to be beneficial in 1953/54. The beneficial effect is probably due to the good lubia associated with insecticidal treatment and not to the insecticides themselves. There is also some indication that insecticides (BHC) increase fallow weeds, possibly because they reduce cockchafer attacks on them.

Clitoria ternatea

The 1953/54 season was not a good one for clitoria. It usually makes good growth during the early winter, but this growth was much reduced by the exceptionally cold weather at that time. The growth of clitoria was noticeably greater during spells of hot weather. A disorder, so far unidentified, affected growth during the rains at Wad En Naim and to a less extent on some Research Farm plots. This disorder is characterised by a mosaic and slight crinkle of the leaves, but there is no definite indication whether it is due to a virus, insect or physiological upset. Though it reduces the production of fodder it does not affect the rotational value of the clitoria. Thrips, grasshoppers and American bollworm were recorded on clitoria, but did not do much damage.

The full experiments started with clitoria in 1953/54 have so far confirmed previous observations on this crop, that it can be established as a mixture with dura or with lubia without affecting either crop. Due to the relatively poor yields of clitoria and the excellent yields of lubia, the clitoria — lubia mixture was not significantly better than lubia alone. Table 31 gives a good comparison of the relative yields of clitoria and lubia and the mixture in 1953/54.

Table 31.

Yields of clitoria and lubia 1953/54

(rotls fresh weight per feddan)

Crop or Mixture	Yield.
Clitoria	15,495
Lubia	29,199
Clitoria-lubia mixture	30,348
Significance	+++
S.E. of treat. mean	± 793
Sig. Diff.	2,191.

The full rotational effect of clitoria has not yet been tested in a proper experiment. Fallows following clitoria and other crops again showed vigorous regeneration of the crop and complete absence of weeds after clitoria. As will be noted later such results as are available indicate that clitoria is as good as, if not superior to, other legumes in the rotation. As in previous years July-sown clitoria was better than August, and August than September. This was more noticeable in 1953/54 because of the cold winter.

In 1953 it was noted that the best flush of flowers and fruit took place in unirrigated 2nd. year clitoria which had been irrigated late and lightly grazed in the previous season. This may be of importance in facilitating seed collection.

Other Legumes

Phillipesara, Cluster Bean and *Phaseolus lathyroides* again gave excellent yields of early fodder. Sown in July they gave approximately eight, seven and six tons green fodder per feddan respectively in October. No new legumes were tried in 1953/54, and others performed as expected. Velvet Bean was sown in May to establish the crop before the usual blister beetle infestation, but it was severely damaged by flooding and waterlogging in August.

Three plots which had a selection of legumes and grasses in 1951/52 and fallow in 1952/53 came into cotton (two) and dura (one) in 1953/54. Though the original layouts were unrandomised, there was some replication and the differences obtained are probably genuine. In all cases the plots following clitoria gave the highest yields. Table 32 gives the record of one of these plots carried through the fallow phase. The cotton yield appears to reflect the combined effects of legumes and non-legumes, and heavy and light weed on the fallows.

Table 32.

Effect of Various Crops on Cotton Yield.

1951/52 Legumes and Grasses		1952/53 Fallow			1953/54 Cotton	
Crop.	Stand	% Regeneration of Crop		Wt. of Weeds kg./fed.	Wt. of Weeds kg./fed.	Yield of Cotton k.p.f.
		Area	Vigour			
Velvet Bean	poor	0	—	176.8	10.4	6.46
Clitoria	full	100	95	31.0	6.7	10.92
Phillipesara	full	87	62	53.7	8.9	9.16
Phaseolus	full	85	60	75.8	6.5	7.78
Sudan Grass	failed	0	—	181.0	7.5	7.17
Sudan Grass	good	100	30	75.4	6.1	6.05
Rottboellia	full	100	30	55.3	25.2	5.06
Anis (*Sorghum purpureo-sericeum*) ...	medium	100	30	119.4	28.9	6.44

Grass-Legume Mixtures

Following promising results in observation plots a statistically designed experiment was laid down to compare Sudan Grass, *Brachiaria* and clitoria, alone and in mixtures. The results given in table 33 confirm those obtained in the 1952 53 observation plot though the general level is lower.

Table 33.

Fodder Experiments

Crop or Mixture.	Yield of Green Fodder (rotls/fed.)	
	ON	2N
(1) *Brachiaria*	7,780	21,360
(2) Sudan Grass	10,620	19,510
(3) Clitoria	14,900	14,450
(4) *Brachiaria* + Clitoria	16,250	27,030
(5) Sudan Grass + Clitoria	14,910	21,640
Significance	++	
S.E. of Treat. Means	± 1,500	
Sig. Diff.	4,020	
C. of V.	17.9%	

The effect of nitrogen on the grasses is as expected, and it will be noted that it has had no significant effect on clitoria. All treatments were watered till March (while other clitoria experiments were stopped in December), and clitoria produced its heaviest cuts in March and April. This late stopping also favoured Sudan Grass compared with *Brachiaria*.

In observation plots in the Northern Gezira and Abdel Magid similar grasses and mixtures were tried and grew reasonably well. In these plots there was some indication that clitoria benefited from nitrogenous fertilizer.

Attempts to form grass-legume pastures on the Gezira clay failed completely, though the prospects for doing this on the river silt are excellent. This is not of practical importance since the areas of silt are so small.

BOTANY AND PLANT PATHOLOGY.

A. Economic Botany.

By K. Wilson Jones

Control of Seid Grass (*Cyperus rotundus*)

Mechanical Methods

The Wad Asha experiment was observed throughout the season, as usual. Numbers 1 and 3, the fallow ones, were Shugadisced in March and May 1953 respectively, and produced virtually no aerial shoots of seid during the ensuing rains. This is the first occasion on which the seid grass has been reduced to negligible proportions in this experiment, and the reason would appear to be the more thorough work carried out by the Shugadisc implement. That the improvement is real may be seen by a comparison with the neighbouring Number 6, which produced a 35% infestation by mid-September.

On the other hand, no significant increases of cotton yield due to the treatment have come to light so far but all the evidence available points to a reduction in yield as a result of the treatment. This may be due to the large amount of soil disturbance caused by the implements. Weeds other than seid grass have also been seen to be heavily reduced by the treatments.

Effect of dry season watering of fallows

Two fallow fields had been treated with the Onions root cutter to control seid in April 1953. 3 mm. of rain fell soon after this and more in the following month but hardly sufficient to cause any survival of tubers whose roots had been cut. The infestation of seid in the rains was estimated to have been reduced from 75% to 5% by the operation. Early in January 1954 one of these plots, which were still fallow, was watered for experimental purposes and a fairly heavy growth of seid resulted accompanied by some nageel (*Cynodon dactylon*). The soil of this plot and the neighbouring unwatered plot was therefore examined early in March 1954 to ascertain the condition of the seid tubers. Four pits were dug in the most heavily infested parts of the watered field C and four in the better parts. Four pits were also dug in places at random in the unwatered field D. Results were as follows:—

Worst parts field C:	average	384	tubers/sq.m.	to 18″.	27% viable
Best parts field C:	average	107	tubers/sq.m.	to 12″.	6% viable
Four places field D:	average	4	tubers/sq.m.	to 12″.	0% viable

It is apparent that the effect of this early watering was to undo most of the good work of the root cutting. Field D which had received only the water of the (good) 1953 rains showed that no viable tubers had developed during that period in competition with the weeds of the summer fallows. Watering outside the normal rainy season in field C however had allowed the seid to grow in the absence of competition, with the results seen. It is noteworthy that the visibly "bad" parts of field C have tubers extending down to 18″. This is probably the result of tubers originally at those depths escaping the root cutter and acting later as centres for reinfestation.

Chemical Methods

A small plot in a field (Nidiana, Abu Kheir 27) heavily infested with seid, was sprayed with 15 r.p.f. of C.M.U. on 1 August by the Gezira Board. Results were observed through the following months. Though further rosettes of the sedge appeared and continued to appear after the top growth had been killed by the spray, they produced only a few leaves and then died off as though the poison took effect only as the aerial growth appeared. This continued until all further active growth of seid grass ceased at the end of the rains. In November 1953 1 x 1 m. square pits were dug and the soil removed in 3″ layers; the tubers were then classified after "germination" tests into living and non-living at each depth. Of the tubers found, 8.2% were viable in the treated area as against 45% in the untreated. There is actually reason to believe that better control could have been obtained had the treatment taken place in July, so as to give a longer growing season during which it could act.

C.M.U. has not previously been tried in the Sudan, being a dollar product. It acts through the roots of the plant, but is not very mobile in the soil, tending to remain near the surface. The top rosettes and bulbs would be killed by the spray itself; tubers at a greater depth would then "germinate" and send up shoots to form each a new bulb and rosette of leaves. This done, the bulb would form new roots in the treated soil, absorb the poison and die. From the depth-distribution of sound but non-viable tubers in the soil it is assumed that the penetration of C.M.U. up to the end of the rains could not have exceeded 6″.

Fallow Weed Observations

S.G.B. Long-term fallow weeding Experiment

It is hoped to publish separately a report on this experiment which has now completed a full rotation of 8 seasons since its inception in 1946/47. The main feature of the current season has been the remarkably uniform weed cover over the whole Gezira, as compared with the normal state of affairs. Remeitab, from an average of about 500 weeds per square metre over the past four seasons, only produced about 300. Turabi, which showed an average of 260 over the same four-year period, had 400 per square metre in the present season. Feteis, Abdel Galil and Tayiba, which have normally averaged 200-300 weeds per square metre, again showed 215, 282 and 264 respectively.

To summarise very briefly the result of eight years' observations :- No striking differences have been revealed as a result of fallow weeding, either on weed populations or the relative numbers of the various species. There has been no large-scale encouragement of perennials, including seid grass. Spectacular effects in terms of soil erosion are likewise unlikely to be encountered, provided that weeding ceases before the last rain capable of cementing the soil surface. (Such an end-of-season rain is incapable of germinating many weed seeds, which by September are mostly in a dormant condition). The next stage in the investigation, the relative efficiency of methods, hand, machine and chemical, is already being taken up by the Board.

S.G.B. SPRAYING EXPERIMENTS FOR FALLOW WEEDING

Experiments were carried out at Hamad el Nil, Barakat, the Seed Farm and Kumor blocks, treated by the S.G.B. and observed by this Section. In each case four alternate fields were sprayed, the intervening fields being left to serve as controls. Each field at each site received one of the four treatments :—(a) 1 lb. sodium M.C.P. per feddan, (b) 1 lb. sodium 2 ; 4-D per feddan, (c) 1 lb. mixture (50 : 50) of sodium 2 : 4-D and 2 ;4 ; 5 T per feddan, or (d) 1 lb. mixture (50 : 50) sodium 2 ;4 ; 5-T and T.C.A. per feddan. All treatments were applied as opportunity served during August ; the latest being (d) on 29 and 30 August. None of these treatments gave a wholly satisfactory control of weeds ; no significant differences were found either in numbers of plants per square metre or in eye estimation of cover over all sites. Considerable further experiment seems desirable, and it is probable that the strength of the solutions will have to be increased. One possible source of the differences between these experiments and those previously reported from the G.R.F. may be that the G.R.F. land is more lightly infested with weeds, except at the height of the rains, than is the normal land of the Gezira.

Control of Buda (*Striga hermonthica* Benth)

Assorted weedkiller experiment

Seven chemicals, supplied by four different manufacturers, all of the hormone weedkiller type, were tested on dura (Feterita 1931) during the 1953 season, at rates equivalent to ½ lb. and 1 lb. per feddan of active agent (acid). A split-plot design was used involving ten replicates of each strength-type combination, as well as sufficient controls. The chemicals consisted of either sodium or amine salts of 2 ; 4-D or M.C.P.A. The crop was sown on 22.7.1953 after the onset of the rains, and irrigated thereafter as necessary. Spraying was carried out on 11.8.53 when the crop was approximately three weeks old. Signs of deformation of the young plants, as noted in previous years, appeared and developed during the following 2-3 weeks but largely disappeared during the following 2 weeks. Clean weeding was practised throughout, as it was desired to test the effect of the chemicals upon *Striga* rather than upon the weeds. Unfortunately for this experiment the Gezira was very free of *Striga* in 1953, probably owing to the very heavy rains in early August, which resulted in much of the young dura being inundated for periods of up to a week. The result of the experiment has therefore been to measure the toxicity of the hormone weedkillers upon the crop, in the effective absence of both weeds and parasites. The infested holes on 17 October averaged :—untreated 3.0%, treated 0.1-0.4%. The differences were not significant being principally due to a single heavily infested control subplot. The fresh weight of *Striga* plants pulled on 10 November from the control subplots averaged 11.5 r.p.f. ; again differences from the treated ones are not significant. Similarly, no significant differences were found between the yields of fresh head

under the various treatments, though all the treated plots yielded less than the control at 2647 r.p.f. Straw yields were all significantly lower as a result of spraying ; some treatments were significantly better or worse than others. These results are to be explained on the grounds that where a certain amount of stand is lost, fewer but larger heads are formed, which compensate for the loss. On the other hand, these larger heads are still borne only on single stalks, so that the loss of stand is mirrored by the reduction in straw yield. The effect of the different strengths of spray was to show progressive though non-significant reductions of yield of heads, and progressive and significant reductions (P=1%) in the yield of straw from 14,100 r.p.f. (control) to 10,300 r.p.f. (1 lb.). The conclusion to be drawn is that although visible damage was caused to the crop by the treatment, the only significant effect was a reduction in the yield of straw. The non-significant reduction in grain yield here seen would almost certainly be compensated in a normal year by the reduction in *Striga* damage, and in any case under native conditions by improved weed control.

Outstation experiments

The belief is held in the Kordofan sands country, that a change of crop from dukhn to dura will result in a reduced infestation of *Striga*, whereas in the Gezira and other dura-growing areas it is considered that the reverse change is beneficial. Two experiments were designed to investigate this. Accordingly, sites were chosen at Kadugli (clay, dura country) and at Um Ruaba (sands, dukhn country) and the same experiment laid down on each. This consisted of a pair of 4 x 4 Latin squares at each site giving permutations of dura and dukhn, sprayed and unsprayed. Spray rates were 1 lb. of sodium 2 ; 4-D in all cases.

Kadugli. The area was sown on 21 June and the selected subplots sprayed on 6 July, after resowing and transplanting (a local practice) as necessary. By 9 September the percentage of infested holes was as follows :- dura sprayed 14%, unsprayed 32%. Dukhn sprayed 0%, unsprayed less than 1%. The spraying was obviously successful in reducing the infestation at this stage. Later the infestation in the sprayed plots increased at a higher rate than in the unsprayed, with the result that the final infestation before harvest was almost as high on the sprayed as on the unsprayed subplots of dura. The infestation on the dukhn, on the other hand, did not increase. Yields were low with both crops. The dura yielded 583 r.p.f. of heads on unsprayed, and 589 r.p.f. of heads on sprayed land. Dukhn yielded 478 r.p.f. unsprayed and 392 r.p.f. sprayed. It would seem that the yield of dukhn is reduced by the spray under the conditions of this experiment.

Um Ruaba. This experiment was sown late. The normal sowing in this area is carried out in late May or early June, on the first rains. Having missed this period, sowing could not be carried out until July 5 ; no further rain fell for 10 days after sowing. By the time of spraying, the crop was in a much weakened state, with only 60-70% of the holes emerged. A second duplicate area was then sown on August 5, and the two areas distinguished by the titles " old "

and "new" respectively. The "old" field was sprayed on July 19 and the "new" on August 19. Stand, infestation and yield were alike poor, primarily on account of the late sowing, secondarily on account of a grasshopper attack which developed on the green dukhn as the surrounding early-sown crops dried off. Very little visible *Striga* attack developed on either plot; least on the later-sown one. The "old" experiment showed infestation as follows:— dura sprayed 1%, unsprayed 0.1%; dukhn sprayed 6%, unsprayed 12%. The "new" experiment showed no infestation except for 3% of infested holes on the unsprayed dukhn. Yields of dry heads were as follows:— "Old" experiment, dura sprayed 326 r.p.f., unsprayed 270 r.p.f.; dukhn sprayed 51 r.p.f, unsprayed 151 r.p.f. "New" experiment, dura sprayed 525 r.p.f., unsprayed 360 r.p.f., dukhn sprayed 310 r.p.f., unsprayed 270 r.p.f.

It is clear from the figures that although the yields mean little or nothing in terms of economic crops in either experiment, the infestation is of a very different nature at the two sites. Um Ruaba is sandy dukhn-growing country, and the *Striga hermonthica* with which it is infested seems to have but little power of attacking dura. Kadugli on the other hand furnishes a clay dura-growing site, not normally used for dukhn, and the *Striga hermonthica* with which it is infested is incapable of making a successful attack on dukhn. Samples of soils and seeds have been taken to ascertain if the differences in behaviour are due to (a) strain differences in *S. hermonthica* comparable to those in parasitic fungi and bacteria, or (b) interactions between crop and soil type influencing the crop's susceptibility to the parasite

Control of Aquatic Weeds

Darwish experimental channels.

The channels of this experimental system, now increased to 24 in number, were again used for a hormone weedkiller experiment. Owing to pressure of work, treatment was not carried out until 19 May 1953, preceded by a survey of the weeds on 15 May which showed the presence of *Potamogeton nodosus* in all channels, *P. perfoliatus* in most, and *Najas pectinata* in several. Treatments used were:—

(1) 10 p.p.m. sodium 2; 4-D (2) 10 p.p.m. sodium 2; 4-D plus 25 p.p.m. commercial slaked lime; (3) 10 p.p.m. sodium 2; 4-D plus 5 p.p.m. phenylacetic acid; (4) 10 p.p.m. sodium 2; 4-D plus 10 p p.m. sodium pentachlorophenate; (5) 10 p.p.m. sodium 2; 4; 5-T and (6) control. There were three replicates of each treatment.

The 2; 4; 5-T was a failure. One channel never became clear, and another showed regrowth by 6 January 1954; the third remained clear until the end of the experiment. 2; 4; 5-T was also found to be slower in acting than the 2; 4-D. 2; 4-D either alone or with pentachlorophenol gave one out of three channels reinfested by January, but the channels treated with 2; 4-D mixed with lime or phenylacetic acid showed no reinfestation.

It is a problem which is still no nearer solution; sodium 2 ; 4-D in these small channels always gives so great a degreee of control, when it has consistently given none or only inadequate control in the canals of the Gezira. The 2 ; 4-D treatment, if it could be made to work in the canals, would probably be economic over a three-year period. The use of lime mixtures on the Turabi system failed to give enhanced control in 1952 53, though it has given an excellent result above. Phenylacetic acid has not been used before ; its addition to the 2 : 4-D follows American work in which phenylacetic acid is mixed in commercial weedkiller for use on water hyacinth (*Eichornia crassipes*), where it is said to give an increased kill of underwater buds.

No large-scale experiments with hormone weed-killers were carried out in season 1953/54.

Continuous application of copper sulphate.

Following upon the experiments in the Wad Matar system of canals reported in the previous season, in which effective control of floating weeds was attained as a result of a large initial dose of copper suphate followed by a small continuous application of the chemical to the water at the head regulator, a further experiment was carried out on the advice of Dr. W. G. Templeman, by the Irrigation Department at Hag Abdulla, assisted by Mr. I. E. Darter of Plant Protection Ltd. and by Senior Economic Botanist. Six canals were chosen for the experiment, which was designed to test :—

(a) if the Wad Matar results could be repeated,

(b) if the initial dose of 30 p.p.m. of copper sulphate was really necessary, and

(c) if application throughout the season was really necessary.

As it appeared that, in the previous experiments, dosages higher than 1 p.p.m. had on occasion been used, the continuous application was standardised at 2 p.p.m. Some of the canals were "summer dry" and others "summer watering". Within the "summer watering" group, some were first treated in August and others in October, with or without the initial 30 p.p.m. dose, and without an initial weeding. The "summer dry" ones were not treated until October, as they contained no weeds when watering was first started in July.

Observations were carried out monthly and weed infestation recorded. Under all treatments the weed began to retreat from the heads of the treated canals and by February 1954 all treated canals were found to be almost completely free of floating weed from the point of application to the last field outlet pipe. The last weeds to disappear were, in order, *Potamogeton perfoliatus*, *P. nodosus* and *Najas pectinata*. In contrast to the cleanliness of the flowing parts of the canals, the ponded portions below the last field outlets were all found to have a heavy growth, particularly of these three species. Samples of water were taken and analysed for copper sulphate by the Botany sub-section, every two weeks so far as possible. These samples showed that, of the average of 2.0 p.p.m. (weighed out and added at the heads of the canals according to the flow rate) of hydrated copper sulphate added to the water, less than 1 p.p.m. was normally recoverable at a distance of 1 km. from the head and below. It would seem that fixation, either as a precipitate or as a complex, proceeds fairly rapidly in the canal water.

On 1 February 1954 it appeared that weed control was almost 100% in the flowing parts of the treated canals, and so no further copper sulphate was added to three of them. Very little, if any, regrowth occurred during the ensuing six weeks until the season's irrigation ceased. At the same time, treatment was started on a further three canals, after weeding. No further weeding was necessary up to the end of the watering season for, not only did the weeds fail to regrow to their original density after the weeding, but many of those which grew at all died off subsequently under the influence of the continuous treatment.

The copper sulphate method is the first chemical one which has been used with any success in the Gezira, but the cost of it used throughout the season in the manner described above is highly uneconomic. Even when it is considered that this application has also controlled the Bilharzia-carrying snails *Bulinus* spp. and *Planorbis* spp. and that the cost of the treatment could on these grounds be reasonably shared between weed and snail control funds, it is still impossibly high. It is known, however, that very little snail breeding occurs during the period of flood water, July-October, when but few weeds appear. Treatment with continuous 2 p.p.m. commencing in October has been shown above to be capable of controlling floating weed by the end of January, with very little regrowth up to the end of the watering season if treatment ceases on 1 February. Treatment commenced on 1 February after normal weeding is also capable of controlling the weed until the end of the watering season. With regard to reductions in the strength of application of the continuous dosage, the Ministry of Health have been applying a continuous dosage of 0.125 p.p.m. in the 70 km. of canals fed from the tail of Bortobeil major. A few analyses of the water of this system, carried out by this Section, have shown that this small amount of copper is not lost at so rapid a rate as the heavier dosages used at Hag Abdulla, and that traces of copper are to be found even in the tails of the system. It has also been shown that the 0.2 p.p.m. dose will give satisfactory control of snails, though not of weeds. Such a treatment from October to January, followed by a herbicidal dose from 1 January to the end of the watering season, may well prove feasible and it is hoped to investigate the possibilities of joint snail and weed control during the season 1954/55.

Aromatic solvents

Samples of emulsified solvents were received by courtesy of Messrs. Plant Protection and I.C.I. Ltd., for trial. Two types were received and portions tried in Gadrin canal (Messellemia sub-division). Both solvents gave an excellent emulsion and were applied at concentrations comparable to those used in American work. No appreciable or lasting control of weed was obtained; 20 gallons of one solvent failed to clear more than 300 m. of canal and regrowth was rapid. The irrigation canals of the Gezira differ from those in many parts of the world on account of their gentle slopes and slow flow rates. The cross-section area of a canal carrying perhaps 7500 m^3 in 24 hours (about 5 m^3 per minute) may be between 2 and 3 square metres and certainly not less than 1 m^2; this gives a flow rate of 5 m. per minute

at the highest, or 300 m. per hour. During 1 hour the losses of solvent by evaporation are considerable and American recommendations (Bureau of Reclamation leaflets) are that a supplementary dose of solvent be added "every $\frac{3}{4}$ mile, or $\frac{1}{2}$ hour, whichever is the sooner". Such applications under Sudan conditions are almost certain to be uneconomic.

The Herbarium

The volume of plants for identification has decreased this year and only 232 specimens have been received for identification. The card-index catalogue of specimens has however been completed almost as far as the end of volume 2 of Andrews' Flora, duplicates have been withdrawn, and a number of new specimens entered. Remounting has proceeded as usual. Duplicates of some of Myers' specimens have been sent to Khartoum University College and Yambio herbaria. It is hoped that, as the cataloguing at Medani and Yambio proceeds, with co-operation from the other herbaria, it may be possible to publish eventually an index to the herbaria of the Sudan. This should save a good deal of unnecessary reference to Kew, and facilitate exchange of duplicates within the Sudan.

B. Plant Pathology.

By S. A. J. Tarr.

Plant Diseases in the Gezira

Cotton (*Gossypium barbadense*, L.)

Blackarm (*Xanthomonas malvacearum*, (E. F. Sm.) Dowson).

This disease was observed in some blocks during September 1953 but no extensive spread occurred and damage in the Gezira as a whole was negligible. At the Barakat Seed Farm, however, some fields sown with seed of Seed Farm origin suffered severe attack, as discussed later. The clean up of fields under cotton in the previous season was completed by the end of June 1953 and is thought to have been very satisfactorily carried out. Sources of secondary blackarm infection were probably slight, and primary (seed-borne) infection did not appear to be any greater than usual. In many blocks, weather conditions were not unfavourable to the development and spread of the disease, and in some localized areas this did take place to a limited extent. In most areas blackarm dried out without having caused serious damage.

Leaf curl, cotton leaf curl virus

Sakel cotton in the northern Gezira was severely attacked by this disease. Scattered infected plants were seen in September, a month or so after sowing. During October the disease became widespread and it was the most severe attack in the present writer's experience (since 1946). Evaluation of damage in terms of crop loss due

to leaf curl disease over large areas is difficult but it is estimated that in some fields as much as 30-40% crop loss can be attributed to the disease with perhaps 10-20% loss for the Sakel area as a whole. In terms of cotton this represents a loss of about 0.75 k.p.f. or nearly 100,000 kantars in all — undoubtedly the most serious damage this disease has caused to Gezira cotton for many years. This season's experience provides a salutary warning that extremely destructive outbreaks of leaf curl can still occur and that the disease can be a major factor governing yields of Sakel. A similar conclusion in respect of blackarm disease was apparent from the heavy outbreak of this disease in season 1951-1952. These experiences should serve to dispel any tendency towards the complacent feeling that leaf curl and blackarm are no longer to be regarded as major factors affecting Gezira cotton yields. Severe outbreaks of these diseases are to be expected if there is any relaxation in the thoroughness with which the present control measures are applied. In parts of the northern Gezira whitefly are thought to have appeared earlier than usual and no doubt ensured early spread of leaf curl. There is no reason to suppose that cotton ratoons were unusually numerous this season but there is evidence that illegal cultivation of bamia (*Hibiscus esculentus*), an alternative host of the cotton leaf curl virus, is increasing within the Gezira and may have been largely responsible for the early and severe leaf curl attack in 1953 54. In most seasons leaf curl becomes evident in Gezira Sakel in November-December but this season it appeared in October. Bamia is a valuable vegetable crop, particularly so during the rainy season (1 June — 15 September) when its cultivation in the Gezira is prohibited by law. Measures to enforce the close season are to be tightened up.

Leaf curl symptoms were occasionally observed on X1730A cotton (leaf curl resistant) in the central and southern Gezira, and what appeared to be a different form of the disease caused considerable damage to X1730L-1 cotton in an observation plot at Abu Guta in the north-western Gezira. Infected plants showed a stunted bunched appearance due to extreme shortening of internodes and marked leaf reduction and distortion. Mosaic and leaf thickening were present in varying degrees and severely infected plants were completely abnormal and produced almost no seed. Nearby pigeon pea (*Cajanus indicus*) showed somewhat similar symptoms. What may have been a similar condition was noted on X1530 cotton at the Gezira Research Farm some twenty years ago. There is no certain evidence that this disease is caused by the cotton leaf curl virus but its destructive nature together with the possibility of its spread to X1730A cotton in the Gezira warrant a detailed investigation.

Other diseases of cotton in the Gezira

Wilt (several causes, sometimes fungal), sooty mould (*Cladosporium* and other fungi growing on insect honeydew on leaves and stems) and boll rots were observed but were not serious. Sun scorching of cotton bolls was prevalent in the northern Gezira at the beginning of 1954 and was associated with widespread premature boll opening. Soft reddish patches, later becoming brown and dry, developed on boll walls where exposed to the sun in the early morning. Those areas of the boll walls shaded by the bracts remained green and healthy.

Young bolls scorched in this way tended to split open before attaining maturity. This condition became apparent after an abnormally prolonged cold spell in late November-December 1953 and it may be that scorching resulted from exposure of the young bolls to strong early morning sunlight when soil temperatures were low and the bolls thereby unable to obtain sufficient water, *i.e.* a combination of water strain and local overheating. In the Gezira, cotton bolls are exposed to strong early morning sunlight every season but scorching seems to occur only after prolonged spells of cold weather. In places the crop had the general appearance of having reached maturity and drying out too soon. There was no indication that these symptoms were in any way caused by a pathogen and they were tentatively attributed to the physiological effects of prolonged cold weather on the cotton plant, though leaf curl may have accentuated the effect in the northern Gezira.

Small observation plots of several varieties of American cotton (*Gossypium hirsutum* L.) were grown in the Gezira this season. Hopi Acala produced poor stands and in laboratory tests the sowing seed gave only about 25% germination. No specific diseases were observed on these American cottons but BAR. 7 8.1 suffered severe wilting late in the season. The tap roots were usually rotted by soil fungi and the condition was attributed to the growing of this (normally) rain grown variety under irrigated conditions which did not suit it; as a result the plants grew slowly, were stunted and were not sufficiently vigorous to withstand attack by soil inhabiting micro-organisms.

Dura (*Sorghum vulgare*, Pers.)

Sphacelotheca sorghi, (Link) Clinton (covered smut) sometimes caused considerable grain losses in places where untreated seed had been sown. *S. cruenta*, (Kuhn) Potter (loose smut), *S. reiliana*, (Kuhn) Clinton (head smut) and *Tolyposporium ehrenbergii*, (Kuhn) Pat. (long smut) were occasionally observed. Anthracnose caused by *Colletotrichum graminicola*, (Ces.) Wilson was sometimes quite severe on young dura. Moderately severe infections of leaf blight (*Helminthosporium turcicum*, Passer.) sooty stripe (*Ramulispora sorghi*, (Ell. and Ev.) Olive and Lefebvre) and suspected bacterial leaf diseases were occasionally noted during the rainy season but the overall significance of these diseases, although unknown, is probably slight.

Lubia (*Dolichos lablab*, L.) and other crops

Bacterial blight (*Xanthomonas phaseoli*, (E.F. Sm.) Dowson) ashy stem blight (*Macrophomina phaseoli*, (Maubl.) Ashby) and occasional suspected virus symptoms occurred but were not serious on late sown lubia. Experimental plots of *Clitoria ternatea*, L. showed severe attacks of mosaic (possibly a virus disease, see below) and widespread dying back of lateral shoots associated with *Macrophomina phaseoli*. In many areas tomatoes suffered severely from leaf curl (unidentified virus disease). Bamia was generally infected with leaf curl and powdery mildews, although the latter were to some extent checked by cold weather in December. Cucurbits and other vegetables also suffered powdery mildew attack in varying degrees.

Cotton

Blackarm

Negligible damage was caused by this disease which was lighter in incidence than for many years past. It was first observed in plot 4 in late September, two or three weeks later than usual, and may have originated as primary (seed-borne) infection in resown holes — but the plants were too old for reliable conclusions to be drawn. Counts of percentages of infected plants in certain standard plots in late October 1953 confirmed that the incidence and severity of blackarm had been the lightest for at least the past six seasons. Possible factors conducing to this abnormally light infection include :—

(a) The small amount of rainfall after 15 August, when sowing starts at the G.R.F. There were 144 mm. in the first half of August but (unlike much of the scheme) only 15 mm. fell in the second half of the month. There was only one day in September with more rain than 10 mm. and none in October. These conditions were unfavourable to the spread of blackarm.

(b) The abnormally heavy rain in May, which was four times the average and most of which (34 mm.) fell in four consecutive days. This rain may have germinated fallen cotton seed to produce seedlings later destroyed by weeding, grazing or subsequent dry conditions. In this way an important source of blackarm carry-over may have been reduced. That this may have happened is suggested by the results of inspections carried out during August 1953 when only small and below average numbers of self-sown cotton seedlings were found. These factors combined with the efficient clean-up of 1952/1953 cotton fields and effective seed treatment led to very light incidence of blackarm disease at the G.R.F. this season.

Leaf curl

Sakel plants with leaf curl symptoms were first observed in plot 52 on 22 October 1953 — as in 1950 and 1952 but somewhat later than in 1949 and 1951. Although present in many Sakel plots later in the season the disease probably caused only slight overall damage — in marked contrast to the severe outbreaks in the northern Gezira. Counts on certain G.R.F. Sakel plots in early March 1954 gave percentages of infection much lower than in the two previous seasons. Ratoon growth during the rains was considerably less than usual.

Other diseases of cotton

Sooty mould (*Cladosporium* and other fungi) growing on insect honeydew on leaves and stems, occasional fungal wilt and purple spotting of leaves and bolls (probably non-parasitic) were all observed but were of little consequence.

A cotton plant one leaf of which bore a tiny patch of powdery mildew was brought in. This plant had been grown for experimental purposes in a tin and when kept under observation in the greenhouse

no further spread of infection occurred. Although there was insufficient material for certain determination the conidiophores and conidia resembled those of *Leveillula taurica*, (Lev.) Arn., a very common mildew on a wide range of plants in the Gezira and the northern Sudan. This species has been recorded on cotton in Russia and can be very destructive to bamia in the Gezira; it may therefore be expected that cotton in the Gezira will eventually be attacked. This pathogen probably consists of numerous specialized races and the evolution of a race virulent to cotton might have serious consequences for the ntensively cultivated cotton fields of the Gezira.

Dura and other cereals

Although cotton sown in mid-August at the Gezira Research Farm received little rain, dura sown a month earlier was exposed to very wet conditions which encouraged the incidence of parasitic leaf diseases and markedly retarded early growth. Anthracnose (*Colletotrichum graminicola*), leaf blight (*Helminthosporium turcicum*), sooty stripe (*Ramulispora sorghi*), grey leaf spot (*Cercospora sorghi*, Ell. and Ev.) and unidentified bacterial leaf diseases were all present and were undoubtedly responsible for appreciable damage. Considerable withering of leaves apparently attributable largely to leaf blight and sooty stripe was observed from August onward, finally drying out with the advent of dry weather later in the season. A case of "green ear" (*Sclerospora graminicola*, (Sacc.) Schroet.) and occasional rust (*Puccinia purpurea*, Cooke) and smutted heads were observed (covered, loose, head and long smuts). Dukhn (*Pennisetum typhoideum*, Stapf and Hubbard) was slightly attacked by rust (*Puccinia penniseti*, Zimm.), leaf spot (*Piricularia grisea*, (Cooke) Sacc.) and downy mildew and green ear (both caused by *Sclerospora graminicola*). Maize suffered slight leaf blight (*Helminthosporium turcicum*) and leaf spotting (*Cercospora* sp.), and negligible rust (*Puccinia graminis*, Pers.) occurred on wheat.

Lubia and other leguminious crops

Bacterial blight caused some damage to early sown lubia but not to the winter crop. Ashy stem blight, sooty mould on leaves and stems (*Cladosporium* and other fungi on insect honeydew) and mosaic (suspected virus) were of little importance. During the rains cowpea (*Vigna unguiculata* (L.) Walp.) was quite severely attacked by various leaf spotting fungi including *Cercospora canescens*, Ell. and Mart., and a few plants with mosaic symptoms were observed. Groundnuts suffered markedly from leaf diseases; some leaf spotting was caused by *Cercospora personata* (Berk. and Curt.) Ell. and Ev. and *Phyllosticta* sp. but in many cases no fungus likely to cause leaf spotting appeared to be present. These leaf diseases of groundnuts would require investigation were the crop ever to be intensively cultivated in the Gezira. In experimental plots *Clitoria ternatea* suffered severely from mosaic stunting and distortion of leaves. This may be a virus disease although the symptoms became less noticeable later in the season. This crop also showed widespread dying back of lateral shoots apparently caused by *Macrophomina phaseoli*. Many legumes were attacked to varying extents by powdery mildews, including *Leveillula taurica* on cluster bean, pigeon pea and broad bean, and *Oidium* sp. on cowpea,

garden pea and *Phaseolus trilobus*. Soya bean in experimental plots was sometimes severely affected by bacterial blight (*Xanthomonas phaseoli*) and haricot bean by ashy stem blight.

Other Crops.

Experimental plantings of castor (*Ricinus communis*, L.) were sometimes attacked by bacterial blight (probably *Xanthomanas ricinicola*, (Elliott) Dowson) and to a lesser degree by leaf spotting (*Alternaria ricini* (Yoshii) Hansf.). Sesame in some plots showed symptoms similar to those of the suspected virus disease which can be so destructive to this crop in the Nuba Mountains. Leaf spotting (*Phyllosticta* sp.) and an unidentified stem rot were occasionally observed. Leaf curl, probably a virus disease, caused heavy losses to tomatoes in G.R.F. gardens as did the cotton leaf curl virus to bamia. Powdery mildews although prevalent appeared to be less severe than usual; probably their development was checked by the cold weather at the end of 1953; they occurred on bamia, tomatoes, cucurbits and other vegetables.

Plant Diseases in the Gash Delta

Possible sources of seasonal carry-over of cotton diseases in the Gash Delta were investigated in mid-September 1953. Sakel ratoons on 1952-1953 cotton fields averaged about two per feddan and some 23% of them showed symptoms of leaf curl infection. X1730A ratoons were numerous since this cotton is cut out at the end of the season whereas Sakel is pulled out. Rainfall in 1953 was exceptionally heavy at Aroma, Tendelai and Metatieb and was well above average elsewhere in the Gash Delta. Considerable rain fell in July-August and must have provided very favourable conditions for ratoon growth. Many of the ratoons inspected in mid-September had been in growth for a considerable time, some having flower buds. Despite these favourable conditions for growth only relatively few Sakel ratoons were found and this is attributed largely to continued efficiency in pulling out of Sakel cotton at the end of the season. However, sources of leaf curl inoculum were sufficient for serious outbreaks of the disease to occur in the 1953-1954 Sakel fields (see below). Blackarm was found on X1730A ratoon cotton in misga Tendelai 11 where infected self-sown cotton seedlings were also present. This is interesting and is to be associated with the exceptionally heavy rainfall at Tendelai this season — in previous years infected volunteer seedlings have not been observed although infected ratoons have occurred. Misga Tendelai 11 suffered a quite widespread attack of blackarm disease in season 1952-53.

Subsequent estimates of blackarm and leaf curl incidence in the 1953-54 cotton fields of the Gash Delta were made in November-December 1953. Blackarm was negligible on all second rotation (*i.e.* later sown) areas and in Hadaliya where rainfall, although above average, was the lightest recorded this season in the Delta (only 22 mm. in September). The disease was worst in four first rotation misgas in which water closure (and presumably sowing) was amongst the earliest in the Delta (early August). Kassala and Degein showed little infection. 1953 rainfall in the Gash was exceptionally heavy, particularly

at Aroma, Degein, Tendelai and Metatieb where it was double the 1942-1953 average. August-September rainfall was highest at Tendelai and Metatieb and, as noted above, blackarm infection was found on cotton ratoons and volunteer seedlings in Tendelai in mid-September 1953. No doubt the disease was mainly seed-borne, since Gezira origin seed is used to sow the Gash Delta, but some infection may have come from 1952-1953 cotton misgas and from wind-scattered debris. Bearing in mind the very heavy rainfall this season it is fortunate and surprising that blackarm was not more severe than it turned out to be. Although considerably heavier than in 1952-1953 and of above average severity for the Gash Delta, it was less severe than in 1950-1951. It is likely that seed from this season's Gash crop will be only lightly contaminate3 with blackarm infection although more so than that from the 1952-195d crop.

Leaf curl was present in all Sakel misgas to a varying extent and was more widespread and severe than in the previous season. Early-sown BLR 14/25 in Tendelai was quite severely attacked and is evidently not sufficiently resistant for early sowing in the Gash. Fair numbers of infected plants were observed in misgas sown to X1730 A cotton (leaf curl resistant). Sakel in Metatieb 3, Tendelai, Hadayaneb and Degein 13 showed widespread leaf curl infection ranging from light to severe in incidence; Bahabini 2, Mekali 1G North, Tendelai 1MW and Metatieb 19 somewhat less so. There was a tendency for the earlier sown Sakel to be more severely attacked than that sown later. Leaf curl appeared early and was present during October in some second rotation Sakel misgas — only a few weeks after sowing. Fairly large numbers of whitefly were reported on ratoon cotton in August-September and no doubt ensured early spread of the disease from infected ratoons to the newly sown crop. Leaf curl undoubtedly caused considerable loss of crop to the Gash Delta Sakel areas this season.

Experimental Work.

Blackarm Disease.

Destruction of seed-borne X. malvacearum.

Research on this project was continued; powder, slurry and steeping methods of treating cotton seed were investigated with special reference to R1489 an experimental organo-mercurial compound supplied by Messrs. Imperial Chemical Industries Ltd. This season's experiments have confirmed that at equivalent mercury contents this substance, whether applied wet or dry, is more effective in destroying seed-borne blackarm infection than mercuric chloride-iodide as at present used. For wet use R1489 also has the advantage of being water soluble. In the accompanying table the results of four replicated field trials carried out during the past two seasons are summarised (trials 3 and 4 in the season under review). These were detailed trials organised on as large a scale as possible with numbers of seedlings per treatment ranging from 30,000 — 50,000 in 10-20 replicates; such large numbers are necessary for statistical differentiation between efficient methods of seed treatment and, as noted below, 50,000 seeds may be sown in less than half an acre in the Gezira.

Treatment.	% Mercury/ seed.	% blackarm infected seedlings. Trial 1	2	3	4
Powders at 1 : 150 *to seed.*					
Abavit B (5.7% mercury) ...	0.038	0.251	0.59	0.787	—
Strong Abavit (8.5% mercury)...	0.057	0.074	—	0.154	0.144
R1489, powder (5% mercury) ...	0.033	0.150	0.16	0.476	0.182
Slurry at 22.5 *ccs/lb. seed.*					
R1489, slurry	0.043	0.076	—	0.040	0.099
R1489, slurry on reginned seed ...	0.043	0.036	—	—	—
Steeping at 150-200 *ccs/lb. seed.*					
R1489, at 150 ccs/lb. seed ...	0.043	—	—	0.015	—
R1489, at 200 ccs/lb. seed ...	0.057	—	—	—	0.017
Mercuric chloride-iodide :					
at 150 ccs/lb. seed ...	0.043	0.068	—	0.358	—
at 200 ccs/lb. seed ...	0.057	—	—	—	0.077
Minimum significant difference P.05 ...		0.102	0.24	0.29	0.071
Minimum significant difference P.01 ...		0.134	0.35	0.38	0.096

Per unit of mercury, R1489 appears to be more effective than mercuric chloride-iodide, and dry powder treatments were less effective than wet treatments (steeping or slurry). For convenience the term "slurry" is here used to denote the application of low volumes of relatively concentrated R1489 solution to the seed with vigorous rapid mixing.

The most effective treatment was steeping in R1489 solution for two hours. The practical application of this process to the 4000 ons of seed needed to sow the Gezira each season presents difficulties It is a lengthy process and the wet seed has to be dried after steeping thus necessitating special drying apparatus; it might not be possible to treat the whole of the Gezira sowing seed within the few months available except by installation of a prohibitively expensive number of machines. An application rate of about 200 c.c. of steep per pound of seed is satisfactory with relatively small quantities of seed but a considerably greater volume per pound of seed would be necessary in large scale application. A further practical difficulty lies in the possibility that, in a continuous steeping process, the seed might selectively absorb either mercurial or water from the steeping solution, thus causing the latter to become weaker or stronger, both of which are to be avoided. This would have to be investigated. If a steeping treatment is adopted, R1489 is to be preferred to mercuric chloride-iodide in that R1489 is more effective and also soluble in water.

Slurry treatment was slightly less effective than steeping but it has the advantage of being a rapid process and suitable machinery for its application to sowing seed could undoubtedly be devised. In ahe experiments described above, fairly clean seed was used and was tdequately damped by about 22.5 c.c. of slurry solution per pound of seed (*i.e.* about 5%). However, this volume might not be sufficient

for effective disinfection of less well ginned seed containing lumps of lint. For slurry treatment the seed must be clean, free from lint and as closely ginned as possible; reginning is highly advisable. Under such conditions a slurry method using modern, high-speed, effective mixers is well worth detailed investigation as a possible method for large-scale treatment of Gezira sowing seed.

From the results obtained in field trials during the past few seasons it was recommended that practical large-scale application of both steeping and slurry methods of treating Gezira sowing seed should be investigated with a view to replacing the present less effective dry powder treatment. Whatever method of treatment is decided on, the organomercurial compound R1489 appears to be more effective and therefore preferable to mercuric chloride-iodide as at present used.

The percentages of infection summarised in the table given above seem small and a truer concept of their practical significance in the field is obtained by considering what they mean in terms of numbers of infected seedlings (*i.e.* infection sources) per acre. Sowing rate of cotton in the Gezira is necessarily high since at least ten seeds (in practice not infrequently twenty or more) are planted in each hole to ensure that clumps of young seedlings are able to force their way through the overlying heavy clay, which becomes very hard when dry. Probably at least 100,000 seeds per acre are sown and with percentage seedling infection reduced to 0.1% there would be about a hundred infected seedlings scattered throughout each acre of cotton. Blackarm spreads with destructive rapidity under warm wet conditions such as usually prevail at the time of cotton sowing in the Gezira and initial infections of this order – 100 infection sources per acre — would lead to widespread and destructive outbreaks. Even the very low percentage seedling infection of 0.01% is equivalent to about ten infected seedlings per acre — sufficient for appreciable blackarm infection should climatic conditions favour spread of the dsease. Thus even small increases in the efficiency of seed disinfection can markedly reduce blackarm incidence. In these experiments naturally infected Sakel seed picked from heavily infected Gezira fields of the previous season was used. Such seed would be much more heavily infected than the Gash-origin seed at present sown in the Gezira. Cotton seed from the Gezira as a whole would carry more infection than Gash seed, and infection in various seed lots would vary from heavy (*i.e.* from heavily infected fields) through moderate to light (from lightly infected fields). Under wet, warm climatic conditions, seedlings grown from seed from heavily infected fields may show nearly one hundred per cent infection and the percentage of infected seedlings produced by any particular seed lot depends partly on the amount of seed-borne infection present and partly on the soil and climatic conditions at and after sowing. During the course of these experiments it was found that untreated, heavily infected seed often gave about 90% infected seedlings when sown under warm, wet conditions in July whereas seed from the same sack gave only some 20% infection when sown under drier climatic conditions later in the season.

Since climatic conditions cannot be controlled, the policy concerning cotton seed treatment in the Gezira must be to strive for the most effective method possible since even small increases in the efficiency of disinfection will result in appreciably fewer sources of infection in the young crop. This becomes even more important if the Gezira is to be sown with Gezira-origin seed.

Several copper compounds were tested for use as cotton seed dressings in the Nuba Mountains where poisonous mercurial dressings cannot be used. Cuprous oxide was the most effective although not as good as mercurials. Copper acetate, sulphate, tartrate, cupric chloride and cuprous chloride showed varying degrees of activity. Certain experimental organic (non-mercurial) seed dressings were tested but none appeared to be as effective as cuprous oxide and the latter is recommended for areas where mercurials cannot be used. The use of cuprous oxide seed dressing for rain-grown American cotton in the Nuba Mountains, where blackarm is often widespread, should reduce the incidence of this destructive disease at a trifling cost per acre.

Blackarm infection carried by seed of Gash Delta and Gezira origin

A sample of untreated Sakel seed from the 1952-1953 Gash Delta crop produced only one infected seedling in some 17,500 (*i.e.* 0 0057%) when sown at the G.R F in July 1953. Similar seed from the Barakat Seed Farm crop gave 0.34% infection (seed from a lightly infected field), 8 69% (from a field with medium infection) and 85.75% (from a heavily infected field.

Alternate howashas of a Sakel cotton number at the Barakat Seed Farm were sown between 22 and 27 August 1953 with seed of Seed Farm origin and with seed of Gash Delta origin. All the seed had been dusted with strong Abavit and precautions to avoid secondary infection were taken. At the end of October counts of infected plants in nine ridges in each angaia were made. Percentage blackarm infection in the howashas sown with Seed Farm seed was 6.3, 35 5, 37.0 and 23 9 (average 25 7%) and in those sown with Gash seed were 0 6, 0.0, 0.15 and 0.03 (average 0 2%). Visual inspection confirmed that infection was noticeably much greater in the howashas sown with Seed Farm seed, despite the fact that it had been treated with extra-strong Abavit. These results indicate what might happen if the Gezira were sown with Gezira rather than with Gash seed although it is to be hoped that Gezira seed as a whole would not carry as much blackarm infection as does seed from the Barakat Seed Farm in many years. Appreciable blackarm infection results from sowing Seed Farm seed, after Abavit treatment, in the Gash Delta if climatic conditions favour development of the disease. The risk of sowing Gezira seed instead of Gash seed in the Gezira is considerable and it is evident that a more effective method of seed disinfection than Abavit would have to be employed.

Phytotoxicity of R1489 solutions to Sakel cotton seed

Some preliminary experiments were carried out in the greenhouse. When used as two-hour steeps at 300 c.c of solution per pound of seed, R1489 solution containing organo mercurial equivalent to 0.13% mercury (hereafter referred to as "% mercury") showed no phytotoxicity; 0.33% mercury solution was slightly toxic, 0 67% markedly so and 1.0% mercury solution was highly toxic. In the latter two treatments, most of the seeds germinated to produce short thickened radicles an inch or two in length and stained brown at the tips. There was no shedding of the seed coat or unfolding of the cotyledons, the latter being crinkled and yellow. Such abnormal seedlings displaying severe symptoms of mercury injury would ra ely survive under field conditions. R1489 solution containing 0.13% mercury showed no toxicity when applied as two-hour steeps at the rates of 150 and 300 c.c. per pound of seed but was slightly toxic at 600 c.c. and somewhat more so at 1200 c c. per pound Phytotoxicity tended to increase with increasing duration of steeping. Methods of drying steeped seed were also investigated; sun drying or quick drying under an electric fan were satisfactory but slow drying indoors or by putting the wet seed in cloth bags had slightly adverse affects on the seed.

Destruction of X. malvacearum carried by infected cotton sticks

Laboratory experiments were continued using the methods described in the 1952-1953 report. With severely infected cotton twigs, dry heat at 75°C. was ineffective even when applied for thirty minutes. Dry heat at 100°C. was more effective and in most cases twigs so heated for 20 minutes were rendered non-infective. Exposure to steam at 100°C. was somewhat more effective and to steam at 1 atmosphere pressure (121°C.) was markedly more so Infected twigs about $\frac{1}{4}$" in diameter were used in these experiments and it is possible that larger twigs and parts of the main stem would be less easily sterilized. On the other hand it is not likely that cotton sticks from most parts of the Gezira would be as heavily infected as those used in these experiments.

LEAF CURL OF COTTON

End of season destruction of cotton plants

This was investigated further using a method in which the stumps of cotton plants cut just above soil level were immediately wetted with various herbicides. This has been found to be more effective than spraying the standing plants and in any event the aerial parts of the plant have to be removed and burnt at the end of the season to prevent blackarm carry-over. With plants cut and treated in mid-April 1953, subsequent ratoon growth (*i.e.* percentage of plants which sprouted) to the end of October was 62.8% in the control subplots (plants cut but not treated with herbicide), whilst DCPA reduced ratooning to 1% when applied as a 5% solution and to 1 7% at 3% concentration. It was more effective than MCPA and TCPA. With plants cut and treated in mid-May 1953 subsequent ratoon growth was 54 7% in the control whilst DCPA and TCPA were about equally effective, both reducing subsequent ratoon growth to 0.3% when used as 5% solutions and to about 1% in 3% concentration. MCPA was less effective. The diluted herbicide solutions were applied at the rate of about 3.3 gallons per acre.

With untreated, April-cut plants, maximum sprouting occurred during early-June to early-July but with May-cut plants the period of maximum sprouting was considerably longer and extended from early-July to the end of August. Thus by 1 July more than 50% of the plants cut in mid-April had sprouted but only 10% in the case of plants cut in mid-May. With plants cut in mid-April the main flush of ratoon growth was over by mid-July although odd plants sprouted for a month afterwards. With plants cut in mid-May the main flush was over by early September but a few ratoons appeared from then until the end of October when the experiment was terminated. It appears therefore that rain in July and August does not stimulate sprouting of all living cotton roots remaining in the soil but that a few ratoons can make their appearance during September and October, a point of considerable practical interest.

Work along these lines will be continued since this method of destruction of cotton plants *in situ* might be used to replace the present laborious pulling out by hand. The latter method is usually very effective in preventing subsequent ratoon growth and any alternative method would have to be equ lly effective. Since there may be some 20,000 cotton plants per acre a very high mortality in treated plants is essential as even 1% subsequent ratoon growth would produce some 200 ratoons per acre and would not be permissible.

Seed dressings for dura

Research on the use of mixed fungicidal-insecticidal dressings for sorghum seed was concluded this season. In a replicated field trial with sowings made in mid-July, mid-August, mid-September and mid-October, seed treatment with mixed fungicidal-insecticidal powders (organo-mercurial or thiram plus 20-40% gamma benzene hexachloride) increased germination and stand by amounts varying from 7.6 to 25.8% (average 16%) as compared with seed treatment using fungicides only. The latter increased germination by up to 12% (average 5%) as compared with untreated seed. Yields of grain and straw were increased to a somewhat lesser extent by these treatments. In this experiment no evident soil pest was observed but it is possible that the BHC protected the sorghum seedlings from attack by cockchafer grubs of the genus *Schizonycha*; these grubs are difficult to detect if present only in small numbers.

In the G.R F. main-crop sorghum plots half of each plot was sown with dur ı seed dusted with 50% thiram (fungicide) powder and the other half with seed dusted with 50% thiram + 20% BHC. Both were used at the rate of one gram of dressing per pound of seed (approximately 1 : 450). In some of these plots no cockchafer damage was evident and only slight differences in stand occurred. In others the BHC treated seed gave better stands, especially so in plot 257 where severe cockchafer attack developed. In this plot, wilting of sorghum seedlings grown from thiram-treated seed became apparent two to four weeks after sowing. The leaves of such seedlings became limp, brown and dry as death occurred. Seedlings grown from thiram-BHC-treated seed were rarely affected and formed good uniform stands. Cockchafer grubs were found in the soil throughout the field

and were attacking the young sorghum roots just below soil level, thus causing wilting and death of the young plants. Stunted and dead plants tended to occur in fairly well-defined patches and showed much variation in incidence. Bare patches several yards in diameter with hardly a surviving plant were not infrequent in angaias sown with thiram-treated seed. Seedlings grown from thiram-BHC-treated seed were rarely attacked although grubs were present in their vicinity, presumably they were repelled by the insecticide. Percentages stand (*i.e.* percentage good holes) and yields were recorded. They showed that incorporation of 20% BHC in the seed dressing had improved stand by an average of some 31.4% and had increased yields of grain and straw by 25-30%. In the most severely attacked angaia (No. 4), stand was reduced to 52.3% as compared with an average of 98% in angaias sown with thiram-BHC-treated seed; grain yield was 880 r.p.f. and straw yield 1.45 tons feddan as compared with an average of 1892 r.p.f. and 2.82 tons feddan in angaias where thiram-BHC-treated seed had been sown, *i.e.*, in this angaia cockchafer grubs were responsible for some 50% loss of crop. The results of this and other experiments indicated that sorghum seedlings could be effectively protected from grub attack by dusting the sowing seed with a powder containing 20% BHC. It is not known how much overall damage this pest causes to sorghum throughout the Gezira. Poor stands of this crop are often seen and it is likely that some of these are caused by cockchafer grubs. Further investigation may well show that they are responsible for causing poor stands and stunted growth hitherto attributed to over-watering, poor seed and other causes. In the Mechanised Crop Production Schemes of the central rainlands it was reported that poor stands of machine-sown sorghum resulted from removal of the sown seed by small ants, *Pheidole rugaticeps* Em. It was found that the use of a combined fungicidal-insecticidal seed dressing largely prevented this, and greatly improved stands and yields. On these considerations it has been decided that in future the standard seed dressing for sorghum seed in the Sudan shall be a powder containing 25% thiram and 20% BHC used at the rate of one gram of dressing per pound of seed. In addition to affording protection against covered smut and certain soil pests this dressing should also reduce the depredations caused by storage pests. It costs about one millieme per gram so that cost of treatment per acre will be up to one piastre (2½d.), depending on sowing rate.

Seed dressings for other crops

Groundnuts

In a replicated field trial, seed treatment of groundnuts gave significant increases in stand and yield. In all cases the seed was hand-sown in regularly spaced holes along the ridges. The treatment of uninjured, intact seed resulted in about 22% increase in stand, 23% increase in yield of nuts and 21.5% increase in dry weight of the harvested plants. With slightly injured seed in which a small scratch was made on one cotyledon the increases were 86%, 180% and 168% in stand, nuts and dry weight respectively and, with seed damaged by prolonged shaking 43%, 135% and 110%; in the last treatment some

of the seeds had split apart. The plot was sown in mid-July 1953 and rain led to considerable flooding. It is evident that, even with apparently intact, undamaged, sowing seed, stands and yields can be considerably increased by use of a seed dressing. With slightly damaged seed such as would inevitably follow mechanical decortication or machine sowing, greatly improved stands and yields resulted from seed treatment. Such treatment protected the seed and young seedlings from attack by soil fungi, reduced seed bed losses and thereby promoted better stands and yields. In these experiments treated, damaged seed gave slightly better results than untreated, undamaged seed but was not quite as good as treated, undamaged seed. Of the seed dressings tested, Agrosan GN (organo-mercurial) and 50% thiram were about equally good while a powder containing 25% thiram and one containing 50% copper as cuprous oxide appeared to be slightly less effective. Incorporation of 20% and 40% BHC in the seed dressings appeared to be beneficial in some cases but was not consistently or markedly so. In all cases the seed dressing was applied at 1: 450 by weight to seed.

From these experiments it is recommended that all groundnut sowing seed be treated with an effective fungicide such as 50% thiram at the rate of 1 g. per pound of seed ; the poisonous organo-mercurials are less suitable. With hand-sown seed markedly better stands will result, especially if damaged seed be sown or if conditions at and after sowing should be unfavourable (*e.g.* heavy rain leading to flooding). With mechanically decorticated seed or with machine-sown seed, both of which will inevitably be damaged, poor stands and yields will almost certainly result from seed rot and pre-emergence damping-off unless the sowing seed is effectively protected by a fungicidal seed dressing. No study of the soil micro-organisms involved in these conditions in the Gezira has been made — isolations from rotting seed and seedlings yielded various fungi, including *Aspergillus niger* and other *Aspergilli*, *Rhizopus* and other fungi and unidentified bacteria. No extensive cockchafer damage occurred in these experiments and it was not possible to determine whether BHC seed dressings were of benefit in this respect, but in the previous season there was no evidence in support of this (see below for further discussion of this subject).

Lubia

In a small experiment an organo-mercurial seed dressing and the same with 20% BHC and 40% BHC added were tested on lubia sown in mid-July and in late October. The seed dressings were used at 1 : 450 by weight of dressing to seed. There were no appreciable differences in the July sowing, all seed giving good germination (about 85%) and yields being about the same in all. In the October sowing, treated seed gave slightly but significantly better germination (average some 11.7% better) and increased yields of fodder by amounts ranging from 13.4% (fungicide only), 22.6% (fungicide + 20% BHC) to 27.1% (fungicide + 40% BHC). There was no apparent wilting or dying of plants in any of the treatments and no evidence of attack by cockchafer grubs.

As with groundnuts there is little evidence that seed treatment with a dressing containing 20% BHC protects lubia from cockchafer grub attack — in marked contrast to sorghum where such treatment gives effective protection. These different responses are perhaps associated with the differences in the method of germination and the root systems of these crops. In lubia and groundnuts the seed, bearing the seed dressing, is carried above ground during germination whereas in sorghum it remains in the soil. Sorghum develops numerous surface roots which are probably less vulnerable to cockchafer grub attack than the more or less well-defined tap root systems of lubia and groundnuts; even an adult plant dies if the tap root is bitten through near the soil surface thus separating the aerial parts of the plant from the roots. Lubia and groundnut plants are often killed by cockchafer grubs a month and more after sowing whereas sorghum plants of that age have usually developed their surface root systems and rarely succumb. If such is the case, seed treatment with BHC powders is unlikely to give protection against cockchafer grubs in plants with epigeal seed germination and well defined tap roots (*e.g.* cotton), but further experiments to investigate this are necessary. A small trial with cotton this season gave inconclusive results due to irregular stands resulting from prolonged flooding of the plot following sowing. It will be repeated next season.

General

Speciments of diseased plants sent in were identified as far as possible and advice concerning them given. A visit was made to the sou hern Fung and collections of plant diseases in this area were made. Several hundred specimens were added to the mycological Herbarium and duplicates of many were deposited in the Herbarium of the Commonwealth Mycological Institute, Kew, whose continuing assistance n this work is acknowledged.

COTTON BREEDING SECTION.

The Gezira Station

By M. F. Rose, L. C. Hughes and A. Low

Climate and Crop

Four features distinguished the present season from that of 1952/53.

(i) the peculiar distribution of the rainfall from July 1 - August 15.

(ii) the absence of weed growth in the young cotton crop.

(iii) with the exception of American bollworm, the absence of pests and diseases generally. The exceptionally heavy rainfall in early August(121.5 mms. from 4th - 7th inclusive) when much of the land was under water for a considerable period probably contributed to the effect of (ii) and (iii).

(iv) the cold spells in the winter.

In the early stages, germination and growth were good and there was no malformation of plant structure (loss of central sympodia) as in the previous season. Some stunting and dwarfing, however, did occur and this was most marked in all American types. (see American Types).

Flea beetle attack was negligible and blackarm and leaf curl counts showed figures of less than 1% infection on all susceptible material. In October, American bollworm was active in all American plots and these became focal points for a spread to the Egyptian types. In the breeding plots there was a marked build-up of whitefly by September 9 and a repetition of the previous season's devastation was anticipated. This, however, did not take place.

Breeding

Egyptian (L Types)

The three groups emerging from the quality filter of the 'breeding plots stage' of the past season and comprising 31, 42 and 37 lots were planted on August 12 — 15th. This marked the 'testing plot stage' (yield) of the new selection procedure adopted in the Sudan. Germination and early stands were good but sporadic termite attack in Group II necessitated yield adjustment.

Yield comparisons on the whole were disappointing. The commercial variety X1730A outyielded (lint) both parental bulks BAR. 4 16 (twice significantly) and BAR. 5 6 (once significantly) in the three trials. There was no significant difference between the mean values of BAR. 4 16 and BAR. 5 6 although the yield of the latter was consistently higher. Three sub-strains only, two from BAR. 4/16 and one from BAR. 5 6 outyielded X1730A.

Twenty-six sub-strains from BAR. 4 16 and eight from BAR. 5 6, not significantly worse than X1730A in yield, were bulked and these two special bulks will constitute the first ' panmixis ' stage to be grown at Shambat. Relevant data from the combined trials are given in table 1.

It should be noted that the three trials were carried out in the complete absence of blackarm, in a season which favoured X1730A throughout the whole Gezira.

Within BAR. 4 16 and BAR. 5 6 variability was low. This fact is the more remarkable in that no active selection has been made within either of the parental bulks since their synthesis by the *bulk* backcrossing technique.

Table 1.

Testing Plot Stage G.R.F. 1953/54.

Type	Genes	Seed* Cotton lbs. acre	G.O.T.	Lint lbs. acre	Boll wt.g.	Lint Index	Weight 100 seeds g.	Seed No. per loc.	Ovule No. per loc.	Mote %	Length mm. mean Max.
X1730A	b_2 b_3	1356	35.5	481	2.4	5.3	9.5	5.5	6.0	7.9	47.3
Parental BAR. 5/6	$B_2B_3R_2RS$	1232	33.7	415	2.2	4.9	9.4	5.2	5.9	10.5	47.3
Special Bulk BAR. 5/6 (8 components)	,,	1305	33.2	432	2.2	4.8	9.6	5.2	5.9	11.6	47.4
Parental BAR. 4/16	B_2B_3	1186	33.7	400	2.2	4.7	9.1	5.4	6.0	11.1	48.7
Special Bulk BAR. 4/16 (26 components)	,,	1251	33.8	425	2.2	4.7	9.1	5.4	6.0	11.2	47.4

* 300 lbs. per acre = 1 kantar per feddan.

Special Problems

Work on the transference of lint retention from *G. contextum* to BLR. 14 25 and the building-up of salt tolerence in BLR. 14,25 was continued. In the latter case, the absence of effective cross-pollination at the Gezira Research Farm (see 1952 53 Report, vicinism) will necessitate either artificial cross-pollination on the spot or the growing of successive filtered 'waves' at Shambat.

Testing

Standard Variety Trials

As in past seasons, the standard variety trials were planted at Turabi (north), the Gezira Research Farm (centre) and Hag Abdulla (south) between 13th and 17th August. The layout was identical : randomized blocks of 9 varieties x 20 replications of plot size 0.01867 acres with spacing 80 x 35 cm. Good germination and initial stands were obtained at all 3 sites.

In the north leaf curl attack was general and in places very severe. In the trial, Sakel and Sakel derivatives were badly affected, only BLJR. 14 29 showing any measure of resistance. Symptoms appeared early in the crop and counts made on 19th February 1954 showed the following infection percentages : Domains Sakel 75.4, BLR. 14/25 75.4, BLR. 14 25.1 80.6, BLR. 14/25.2 74.2, BLJR. 14/29 43.2. The American types, Wilds SUS 16 1 (glabrous) and P 268F (strongly hairy) although showing no visible symptoms of the disease were dripping with asal (honeydew) by mid October, a measure of the severity of the whitefly attack. Only X.730A and derivatives showed normal growth, although their final yields must have been considerably reduced by direct whitefly action. In consequence the L group outyielded the S group by 115 lbs. of lint per acre, a highly significant difference. In the complete absence of blackarm, Domains Sakel showed its superiority to all BLR. and BLJR. derviatives for the second successive season. Of the American types, Punjab 268F headed the yield list with 594 lbs. of lint per acre, a significant increase over Wilds of 72 lbs.

In the centre, at the Gezira Research Farm the trial was remarkably free from all pests and diseases. There was little loss of bottom and central sympodia in Sakel types as in the previous season but dwarfing and stunting of American types was marked. Egyptian types displayed similar symptoms but to a lesser degree. This general patchiness was sporadic, with no definite trends. As in the north, the L group again showed its superiority over the S group with a significant yield difference of 59 lbs. of lint per acre. BLR derivatives showed the same general trend in relation to Domains Sakel although yield differences in favour of the latter were not so marked. Punjab 268F again responded well, giving 588 lbs. of lint per acre. Wilds SUS 16 1 was disappointing : marked dwarfing of the plants was responsible for its low yield of 470 lbs. lint.

In the south at Hag Abdulla the trial suffered a serious setback in mid-October from American bollworm. Fortunately the whitefly build-up was not very serious and the trial gave fair yields. The L group outyielded the S group by 82 lbs. of lint per acre, a significant difference. Domains Sakel again surpassed in yield all derviatives from it with BLJR. 14 29 disappointingly low. Punjab 268F gave the highest yield (560 lbs. lint) of all varieties tested, with BAR. 7/8.1 the lowest (413 lbs.).

As a fair generalisation, the season eminently suited the L types throughout the Gezira: the overall yield (581 lbs. lint per acre) of Punjab 268F is also worthy of note.

Relevant data for the 1953 54 trials are given in table 2 with summarized performance for yield and spinning test figures in tables 3 and 4.

Table 2.

Gezira Variety Trials 1953/54.

Yields of Seed Cotton and Lint in pounds per acre.

Variety	BAR. Genes	Turabi (North)			G.R.F. (Centre)			Hag Abdulla (South)			Overall Mean		
		Seed Cotton	Lint	G.O.T.	Seed Cotton	Lint	G.O.T.	Seed Cotton	Lint	G.O.T.	Seed Cotton	Lint	G.O.T.
S. Group.													
Domains Sakel		1362	434	31.9	1707	551	32.3	1605	508	31.7	1558	498	32.0
BLR. 14/25 Gash	B_2B_3	1263	393	31.1	1678	534	31.8	1554	477	30.7	1498	468	31.2
BLR. 14/25.1 Abu Guta ...	B_2B_3	1193	377	31.6	1640	523	31.9	1549	462	29.8	1461	454	31.1
BLR. 14/25.2	B_2B_3	1231	388	31.5	1673	529	31.6	1478	451	30.5	1461	456	31.2
BLJR. 14/29 Abu Guta ...	B_2B_3	1212	393	32.4	1491	490	32.9	1374	442	32.2	1359	442	32.5
L. Group.													
X1730A Gash		1424	525	36.9	1576	575	36.5	1600	557	34.8	1533	552	36.1
BAR XL-1 Gash	B_2	1371	498	36.3	1647	593	36.0	1612	543	33.7	1543	545	35.3
American.													
Wild SUS 16/1		1567	522	33.3	1423	470	33.0	—	—	—	1495	496	33.1
Punjab 268F	B_2+	1708	594	34.8	1670	588	35.2	1592	560	35.2	1656	581	35.1
BAR. 7/8.1	B_2B_3	—	—	—	—	—	—	1134	413	36.4	1134	413	36.4
Standard Error (Mean)			11.1			18.5			18.4				
Difference P = 0.05 ...			30.9			52			51				

Table 3.

Summary of Performance of Current Strains in Gezira Variety Trials up to and Including season 1953-54.

Variety.	Basic Type	Seed Cotton (lbs./acre)						Lint (lbs. acre)						Location
		No. of Trials	Mean			Variety as % of		No. of Trials	Mean			Variety as % of		
			Variety	X1730A	Dom Sakel	X1730A	Dom Sakel		Variety	X1730A	Dom. Sakel	X1730A	Dom. Sakel	
Domains Sakel		15	1330	1372	1330	97	100	15	428	483	428	89	100	Northern Gezira
BLR. 14/25	S.	4	1560	1546	1603	101	97	4	507	572	534	89	95	
BLR. 14/25.1	S.	2	1425	1510	1565	94	91	2	471	567	523	83	90	
BLR. 14/25.2	S.	1	1231	1424	1362	86	90	1	388	525	434	74	89	
BLJR. 14/29	L.	1	1212	1424	1362	85	89	1	393	525	434	75	91	
X1730A	L.	15	1372	1372	1330	100	103	15	483	483	428	100	113	
BAR. X1730L-1	L.	11	1348	1431	1425	94	95	11	483	517	466	93	104	
Wilds SUS 16/1		2	1605	1511	1566	106	102	2	538	568	524	95	103	
Punjab 268F		1	1708	1424	1362	120	125	1	594	525	434	113	137	
BAR. 7/8.1		—	—	—	—	—	—	—	—	—	—	—	—	
Domains Sakel		28	1581	1861	1581	85	100	28	501	657	501	76	100	Central Gezira
BLR. 14/25	S.	4	1409	1385	1193	102	118	4	451	509	395	89	114	
BLR. 14/25.1	S.	2	1554	1619	1522	96	102	2	497	595	499	83	100	
BLR. 14/25.2	S.	1	1673	1576	1707	106	98	1	529	575	551	92	96	
BLJR. 14/29	L.	1	1491	1576	1707	95	87	1	490	575	551	85	89	
X1730A	L.	28	1861	1861	1581	100	118	28	657	657	501	100	131	
BAR. X1730L-1	L.	12	1679	1566	1294	107	130	12	597	565	419	106	142	
Wilds SUS 16/1		2	1752	1620	1522	108	115	2	584	595	499	98	117	
Punjab 268F		1	1670	1576	1707	106	98	1	588	575	551	102	107	
BAR. 7/8.1		—	—	—	—	—	—	—	—	—	—	—	—	
Domains Sakel		11	1302	1454	1302	89	100	11	417	515	417	81	100	Southern Gezira
BLR. 14/25	S.	4	964	967	799	100	121	4	295	339	254	87	116	
BLR. 14/25.1	S.	2	1118	1205	1113	93	100	2	339	422	354	80	96	
BLR. 14/25.2	S.	1	1478	1600	1605	92	92	1	451	557	508	81	89	
BLJR. 14/29	L.	1	1374	1600	1605	86	86	1	442	557	508	79	87	
X1730A	L.	11	1454	1454	1302	100	112	11	515	515	418	100	123	
BAR. X1730L-1	L.	11	1359	1234	1021	100	133	11	474	434	331	109	143	
Wids SUS 16/1		—	—	—	—	—	—	—	—	—	—	—	—	
Punjab 268F		1	1592	1600	1605	99	99	1	560	557	508	100	110	
BAR 17/8.1		1	1134	1600	1605	71	71	1	413	557	508	74	81	

Table 4.

Summary of Spinning Test Reports on Current Strains in Gezira Varietal Tests 1942-43 to 1952-53.

	Effective Length 32's.				Standard Hair Weight			Corrected Lea-Strength Products.					
	Type	No. of Trials	Mean		No. of Trials	Mean		No. of Trials	Mean of 80's Counts		No. of Trials	Mean of 100's Counts	
			Variety	Dom. Sak.		Variety	Dom. Sak.		Variety	Dom. Sak.		Variety	Dom. Sak.
BLR. 14/25	S	6	47.0	45.5	6	150	151	6	2541	2543	6	2261	2229
BLR. 14/25.1 ...	S	3	46.0	45.3	3	153	155	3	2454	2483	3	2242	2251
		No. of Trials	Variety	X1730A	No. of Trials	Variety	X1730A	No. of Trials	Variety	X1730A	No. of Trials	Variety	X1730A
BAR. X1730L-1 ...	L	20	46.6	46.1	20	162	162	28	2074	2071	19	1861	1865
BAR. X1730L-3 ...	L	6	45.3	45.8	6	167	163	6	2249	2250	6	1903	1930

MISCELLANEOUS

(a) At the Gezira Research Farm, a randomized block experiment (11 replications) was laid down on August 15 to test X1730A (commercial bulk) against BAR. XL-3. Unfortunately sufficient seed of the latter was not available for the standard trials. In the past two seasons, BAR. XL-3 has shown a marked response to the wetter conditions of the centre and south, outyielding (lint) X1730A by 9% and 37% respectively. Figures in table 5 indicate a complete reversal of performance, X1730A outyielding BAR. XL-3 by 8%.

Table 5.

VARIETY.	Lint (Lbs/acre)	G.O.T.
X1730A	558	36.5
BAR.XL-3	517	36.0
S.E. (mean)	9	
Sign. diff. (P = .01)	41	

(b) With the exclusion of BAR. 12/9, the Tokar trial of the previous season was repeated. XAT. 1, XAT and XAG were replicated 10 times in a randomized block experiment planted on September 28. The origin of XAT. 1 and XAT (possible shade-tolerant genotypes within the Gash-Gezira crop, XAG) and their acclimatization at Tokar was discussed in the 1952/53 report.

The results, as shown in table 6 are disappointing. They do not confirm the general postulate and do not agree with the findings of the previous season.

Table 6.

VARIETY.	Lint (lbs/acre)	G.O.T.
XAT.1	180	33.1
XAT	134	29.9
XAG	206	33.2
S.E. (mean)	13.3	
Sign. diff. (P = .05)	39.5	

AMERICAN TYPES

At the request of the Gezira Board, much time was devoted to a survey of American types grown under irrigation. Local rain-fed types were included together with introductions from overseas. Such a step did not admit of any drastic change in general policy but was undertaken in the light of (i) the very rapid fall in the price of Egyptian types in relation to that of American and a possible shift in demand to the shorter staple cottons, (ii) the increase in area envisaged for the main Gezira crop and (iii) the question of water economy in terms of water stoppage in December.

Nine varieties were grown, five Sudan rain-fed types and four introductions from abroad. The former were represented by BAR. 10 3 (Deltapine carrying B_2). BAR. 11 5 (XA 129 ex Pump Scheme Strain carrying B_2), BAR. 11/7 (XA 129 carrying B_2 and B_3), Wilds SUS 16 1 (an American irrigated originating from Zeidab) and BAR. 7 8.1 (BAR.SP 84 carrying B_2 and B_3) : the latter by Punjab 268F ex Pakistan 1952 and 1953, a very early prolific type, blackarm resistant, jassid resistant and tolerant of salty conditions under irrigation with staple length flat 15 16″; Hopi Acala ex U.S.D A. 1953, an early prolific type with high intrinsic fibre strength possibly carrying B_2 and B_3, with staple length 1″ ; and Tanguis (types CNPC 46 and 47) the distinctive monopoly cotton of Peru and highly favoured by various section of the trade.

Following their standard practice, the Gezira Board planted four of the most likely types, Punjab 268F, Hopi Acala, Wilds SUS 16 1 and BAR 7 8.1 in strips up to 10 acres at Kab El Gidad (north), Nidiana (centre) and Hosh (south). The Cotton Breeding Section undertook to make a detailed study of all nine types at the Gezira Research Farm (centre) with the two Tanguis strains also under observation at the Prison Farm, Abdel Magid (north). General allocations between the Gezira Board and the C.B.S. were governed by the quantity of seed available.

With the possible exception of Punjab 268F, the season and conditions generally did not favour these American types although they did better in the north than in the centre and south. Wilds SUS 16/1 which can be treated as an acclimatized American control, showed the same general trend from north to south and, in terms of previous seasons' figures, yield was down although its high quality was maintained.

At all 3 Gezira Board sites, BAR. 7/8.1 appeared unhappy : early leaf yellowing followed by rapid senescence and leaf shed marked the progress of this strain. Contrary to expectations however, its final overall yield was high with grade figures close to Wilds (see table 7).

Table 7.

American Types : Gezira Board 1953 54.

Overall Means (3 sites).

Variety	Area (acres)	Seed Cotton lbs/acre	Lint lbs/acre	G.O.T.	Mean Grade
Bar. 7/8.1	30	1,301	476	36.6	2.1
Wilds SUS 16/1	30	1,407	462	32.9	1.7
P 268F	15	1,229	429	34.9	3.1
Hopi Acala	19	870	272	31.3	2.5

Much of the Hopi Acala was non-viable : hence depleted stands and poor yields.

At the Gezira Research Farm, growth and plant development were poor, poorer in fact than at Nidiana. Tanguis, although showing its characteristic 'whiteness' and 'leafiness', showed symptoms of blackarm, leaf curl and jassid attack (Abdel Magid). It was extremely late, a fact which would militate against its introduction into the general Gezira regime. BAR. 7/81 again produced a miserable plant (although yields were fair) while BAR. 10/3. gave poor yields of very inferior quality.

In fact, over the four sites 3 types only have emerged worthy of further consideration (i) Punjab 268F, (ii) Hopi Acala and (iii) BAR. 11/7. With ample seed available of BAR. 7 8.1, the two former will be bulked up in isolation at Wad en Nau (25 acres each) while BAR. 11/7 will be multiplied at Kadugli. Such seed will be held in reserve against any future emergency.

The peculiar behaviour of American types generally in the present season warrants further investigation. Work on 'salt tolerance' under controlled conditions has indicated that the Americans are less tolerant of saltiness than the Egyptians. It is possible that under certain conditions this factor may play an important part in the root-shoot relationship giving general unbalance to the plant.

Detailed characteristics of the 9 types under survey (with appropriate Egyptian controls) are given in table 8.

Table 8. Survey of American (*G. hirsutum*) and Egyptian (*G. barbadense*) Varieties. G.R.F. 1953/54, Planted 15.8.53.

Observation	Sample	BAR 11/7	BAR 11/5	P268F	Hopi Acala	BAR 7/8.2	Wilds 16/1	BAR 10/3	Tanguis 46	Tanguis 47	X1730 A	Dom Sak.	BLR 14'25
Node Number (M)	30 plants	8.7	8.7	8.3	7.7	7.4	7.4	6.9	17.6	16.9	13.9	11.3	12.2
Plant Height (ins.)	20 plants	19.5	19.5	23.4	19.7	17.8	16.4	20.0	32.4	34.4	27.5	35.0	33.4
Hairiness (Leaf) L.	Visual Assessment	2	3	3	0	2	0	1	1	2	0	0	0
D.		2	1	3	0	3	0	2	5	5	0	0	0
Scale 1-5 with increasing Length and Density													
Av. Days to 1st square	30 plants	40	40	38	41	37	39	39	64	63	44	44	43
Av. Days to 1st flower Approx. 50% of sample	60 plants	56	57	56	57	54	56	57	92	92	79	69	69
No. Fruiting Points: Days from sowing 40	10 plants	2	2	2	1	3	2	2	—	—	—	—	—
70		15	15	23	15	17	19	22	2	2	7	11	10
80		22	22	32	24	23	30	30	6	7	20	17	21
90		—	—	—	36	—	—	—	20	23	36	29	32
110		—	—	—	—	—	—	—	26	28	38	30	32
140		—	—	—	—	—	—	—	31	32	—	—	—
Maturation Period (boll)	25 bolls	55	57	53	52	59	59	56	73	75	73	65	62
No. of locules 3 loc	60 bolls	5%	9%	—	2%	4%	7%	2%	100%	100%	97%	95%	100%
4 loc		86%	71%	50%	84%	80%	90%	82%	—	—	3%	5%	—
5 loc		9%	20%	50%	14%	16%	3%	16%	—	—	—	—	—
Seed Characters: Seed coat nep. (roller gin)	600 seeds	22%	35%	40%	40%	59%	17%	49%	—	—	—	—	—
Boll. Wt. (gms.)	60 bolls	3.52	3.82	4.90	4.51	4.20	5.43	4.95	3.60	3.55	2.8	2·8	2.5
Seed number/loc.	60 bolls	6.6	7.1	7.1	6.3	6.6	7.0	7.2	7.0	7.0	5.9	5.8	5.6
Seed Weight (gms.)	600 seeds	8.9	8.9	9.6	11.3	9.6	13.0	10.0	10.2	10.2	10.4	11.0	11.0
Lint Index (gms.)	600 seeds	4.3	4.6	5.3	6.0	5.7	6.8	6.5	6.9	6.8	5.3	5.2	4.9
G.O.T.	60 bolls	33%	33.5%	35.5%	34.0%	36.5%	34.5%	39%	39.5%	38.9%	33.1%	32.0%	31.2%
Lint Length mms.	30 seeds												
(1) Mean Max.		37.5	35.8	31.3	33.1	34.7	46.3	37.6	45.0	45.4	46.9	46.1	46.5
(2) Butterfly		32.0	30.4	26.7	27.3	29.0	39.3	31.2	39.5	39.0	40.8	41.2	40.8

Shambat Station

by R. L. Knight, S.O.S. Dark and J. H. Saunders

Meteorology.

Rain began half way through July and continued until the end of September. The total rainfall for the season was 156 mm. An exceptionally cold winter retarded the germination of out-of-season plots and rendered them largely ineffective. The monthly mean maximum ranged from 42.1°C in May 1953 to 29.5 in December 1953, with a mean maximum of 35.4°C for the year.

Genetics

Production of 'Egyptian' varieties resistant to blackarm and leaf curl

Domain Sakel derivatives.

BLR. 14/25.3 (B_2 B_3 + leaf curl resistance). Roguing for leaf curl was carried out on the 1½ acre plot sown in March 1953 (see last season's report), and 3,213 (42%) infected plants were removed leaving 4,404 healthy plants. Seed from the healthy plants was used to sow a propagation area of approximately seven acres in October 1953, and seed from this plot will go to the Gash for further propagation next season.

Other blackarm resistance transferences to Sakel and X1730

In the transference of the *arboreum* intensifying gene, B_6m, to BAR. 4/16, selfed seed was produced from which F_3 lines homozygous for B_2, B_3 and B_6m can be grown next season. The BAR 5/6 transference is one generation behind this.

Small propagation plots of Sakel and X1730 types, homozygous for B_2 and B_6m, were grown during 1953-54 winter but the transference of B_6m to BLR 14 25 was held up owing to the loss of this line in the breeding plot. This will necessitate going back to an earlier generation of seed.

Gene homology tests on Sakel carrying blackarm resistance transferred from *G. herbaceum* are not yet complete but it appears probable that *herbaceum* carries a gene not previously encountered.

A recessive blackarm resistance gene from *G. anomalum* was given the symbol b_8 and shown to be closely linked with the R_2 locus with a crossover value of about 1.4%.

In checking the homology of transferred Asiatic genes (1950-51 report, p. 41) the F_2 of two B_4B_4 Sakels was grown. These two B_4 Sakels originated from two separate auto-allotetraploid transferences and the F_2 results proved that in both cases the transferred gene, B_4, went to the same locus in the AD genom.

Transferences involving B_6m.

The transferences of the *arboreum* blackarm resistance intensifying gene, B_6m, from synthesized Sakels to Uganda BP52 derivatives and to BAR. 11 7, BAR. 7 8.1, BAR. NT96.1, BAR. 10/3, BAR 20/1 and Wilds SUS 16/1 was continued (see last season's report). In the case of Wilds SUS 16/1 and of BP 52 derivatives not carrying B_2, viz C (51) 22-6, C (51) 17-1 and C (51) 17-4 the genes B_2 and B_6m are being transferred together.

BAR. 7 8.2—The two acre propagation plot of BAR. 7/8.2 sown in March 1953 yielded seed for the variety trials in the rainlands and also for sowing some 16 acres from September 1953 onwards. Within this second increase area, a search was made for plants free from seed-coat nep, utilizing the findings of Evenson at Namulonge, and 21 nep-free plants were found. Natural seed of these 21 plants was bulked and sown in about ½ acre in February 1954. This area will be rogued down, by culling all plants with nep, and then expanded as BAR. 7 8.3.

Wilds SUS 16/1. — Seed was produced from which a strain homozygous for B_2 can be obtained next season.

Jassid resistance

In the transference of MU8b hairiness to blackarm resistant Sakel, fifth backcross F_3 lines were obtained with excellent hairiness, some sixth backcross F_1 material was grown out-of-season, so that next season's plots will carry both F_1 and F_2 lines of sixth backcross type.

The transference of the Ferguson hairiness complex is ahead of the MU8b work. A homozygous bulk was selfed out from the seventh backcross and given the number BLJR. 14 36. This type shows adequate hairiness for good jassid resistance, and in addition is homozygous for B_2 with or without B_3. It also shows some leaf curl resistance. It is not known whether the lint of BLJR. 14 36 is up to standard but it seems likely that the hair weight will be above that of Sakel. Further backcrosses have been made in order to render this material homozygous for B_3 as well as for B_2 and to improve the lint quality.

The basic hairiness gene transferred from tetraploid *arboreum* (Multani) to Sakel was shown to be H_1.

Work on the transference of jassid resistance to Wilds SUS 16/1 was continued, using as recurrent parent in this generation, material carrying B_2 with a view to producing a substrain of Wilds carrying resistance to both jassid and blackarm.

The association between H_2 and a reduction in staple length, noted by Simpson (1947) in T611 hybrids and by Patel and Thaker (1950) in *tomentosum* crosses, has been shown to be due to linkage and not to pleiotropy. Lines of blackarm resistant Sakel are now available with full staple length and these may prove of value for adding length of lint to shorter stapled types by the process of carrying H_2 through a few backcrosses and selfing out. It is unfortunate that H_2 reduces

plant height and presumably reduces yielding capacity. A similar, though lesser, effect is noted with H_1 transferences to Sakel: the H_1 lines are slightly reduced in height and tend to be lower yielding than the Sakel controls.

BLJR. 14 29 (Sakel + H_1 + B_2 B_3) shows moderate leaf curl resistance and this variety has been heavily rogued for leaf curl this season in order to increase this resistance. BLJR. 14/29 is not a commercial type, but is being used as backcross parent in hairiness transferences. Even though this variety has proved lower yielding than BLR. 14/25, it has been necessary to use it as recurrent parent for a limited number of generations in order to 'wean' the Ferguson minor hairiness gene complex from H_1k (which is unbreakably linked with a factor for chlorophyll deficiency) and use it in association with normal H_1.

Work with *G. mustelinum*, St. Ignatius (*marie-galante*) and Hairy Giza 36 is being discontinued since it is clear that these types will not provide any new major hairiness genes.

Yield

The transference of 4- and 5-loculed bolls from Ferguson, Stoneville 20, Clevewilt 7, Punjab 268F and 244F, and Pubescent T611 to BLR. 14/25 is proceeding. The Ferguson transference reached the seventh backcross and from this material it is hoped to start selfing out 4-loculed lines next season.

Transference of increased ovule number per locule from *G. auritum* to BLR. 14 25 has continued. The evidence from this work to date strongly suggests that the character is polygenic and that no major gene is involved. Selections for high ovule number were made in backcross F_2s and these were again backcrossed to BLR. 14/25 and selfed.

Exploitation of wild Gossypium species

G. thurberi work on the transference of high lint strength to 'Sakel' was continued using BLJR. 14/29 as backcross parent.

G. anomalum. 106 plants were obtained from backcrossing the pentaploid plants mentioned in last season's report with BLR. 14/25.1. In backcrossing to BLR. 14 25.3 forty-one of these plants proved female fertile. Plant appearance varied greatly, but many of the plants possessed leaf hairiness comparable with that of *anomalum* and only four of the forty-one fertile plants were glabrescent. The majority of the progeny inherited the toughness characteristic of *anomalum* leaves. The narrow bract of *anomalum* which was one of the characters sought in this cross did not appear.

Detailed records were made on all of the 106 plants, including their floral morphology. Nearly all the plants were unstable in some floral character.

Other species. The seed of 8 crosses between wild species and New World cottons was treated with colchicine solution but no hexaploid plants were obtained.

Pentaploid families have been grown from the crosses of 5 American hexaploids with BLR. 14/25.2. The crosses with *G. harknutum* and *G. herbasutum* failed to produce families.

This season we have concentrated on obtaining self bred seed, as seed stocks of many forms had become dangerously depleted.

Bollworm Resistance

In the transference of resistance to pink and Egyptian bollworm from *G. thurberi* to BAR. 11/7 segregates differing markedly from the controls in bollworm infestation were obtained in material of (G. 'thurbadense' x Sakel) x XA129[2]) x BAR. 11/7 F_1 composition. In general appearance the plants were very similar to BAR. 11/7, itself a derivative of XA129. Controls of BAR. 11/7 were scattered in the plot and all open bolls in both families and controls were examined for bollworm damage, but no attempt was made to classify the material into damage by pink, Egyptian, American or Sudan bollworm. In the figures tabulated below, the four best selections are compared with the control.

Bar. 11/7 (av. of 200 plants.	Healthy Locs.	Partly diseased Locs.	Fully diseased Locs.
	10.4	53.4	135.0
PE18/53.128	134	106	80
„ 134	171	121	73
„ 136	109	28	19
PE20/53. 23	138	63	51

The two control plants with least bollworm damage and the two with most bollworm damage gave respectively:

		Healthy Locs.	Partly diseased Locs.	Fully diseased Locs.
Bar.11/7	Two best plants	39	79	145
		12	38	50
	Two worst plants	0	41	186
		7	95	269

Fifteen plants showing the least bollworm infestation were chosen for further backcrossing to BAR. 11/7 and for selfing.

In the transference of resistance to BLR. 14/25, much more variable results were obtained and it seems probable that whereas in the BAR 11/7 crosses the portion of thurberi chromosome concerned with resistance had crossed in to the genom, in the BLR. 14/25 crosses this had not yet occurred. It seems that in backcrossing D AD hexaploids to New World (AD) cottons, it is important to change from *barbadense* to *hirsutum* (or vice versa) for one or more crosses early in the hybridization programme, to facilitate the 'crossing-in' of the New World wild D genom (Knight, 1954).

In transferences involving *armourianum* via the hexaploid *G.* '*armadense*', considerable sterility was still encountered but a number of plants which appeared to carry bollworm resistance were selected for further backcrossing to BLR. 14/25.3.

Earliness

Work on the transference of earliness from *G. arboreum* and *G. herbaceum* to BLR. 14/25 was continued.

Hormone treatment

Plants of a triploid family at Shambat and Medani were used to determine the optimum concentration and number of applications of hormone solution required to prevent shedding of the bolls. Concentration of 2000, 1000 and 500 p.p.m. with 1, 2, 3 and continued applications at weekly and fortnightly (Medani) intervals were tested. At Shambat, 1,000 p.p.m. solution gave the best results with 1, 2 or 3 applications equally effective, resulting in approximately 25% bolls from the treated flowers. At Medani all the treatments were equally effective and bolls matured from 80-100% of the treated flowers.

Type Collection

Uplands from U.S.A., Central America, South America, Russia and Asia were grown at Medani and surveyed comprehensively, emphasis being placed on economic characters. Certain lines with glabrous leaves appeared to show some jassid resistance and this observation will be checked next season in a small replicated experiment.

The cataloguing of the Type Collection is being reorganised and the revised lists will be available by the end of 1954.

Diseases and Pests

Shambat again suffered an outstandingly heavy attack of pink and Egyptian bollworm. Towards the end of the season a technique of putting white paper bags over the flower buds, for self or cross-bred bolls, was used with marked success, bollworm damage being greatly reduced. This technique was started by Mr. Saunders, who had used it with success in Nigeria.

Kadugli Station.

by M. F. Rose and A. Low

General

At Kadugli, rains were well above average with fair distribution. Rainfall figures for the Kordofan cotton area are shown in table 9 with temperatures for Kadugli appended.

Table 9.

Rainfall mm.

Station	Month								Total
	April	May	June	July	Aug.	Sep.	Oct.	Nov.	
Kadugli (Feb. 0.2 mm.)	30.5	131.8	164.4	184.5	214.0	211.2	73.0	2.5	1012.1
Dilling ...	17.0	35.0	96.0	104.5	222.0	158.5	—	—	633.0
Lagowa ...	20.0	91.0	161.0	243.5	218.5	133.5	14.0	—	881.5
Talodi ...	38.5	78.0	161.5	284.0	218.0	110.0	93.0	9.5	992.5
Kalogi ...	5.0	35.0	93.0	237.0	198.0	157.0	98.0	6.0	829.0
Umberembeita	—	45.5	107.0	166.0	174.5	129.5	49.5	13.0	685.0
Abu Gubeiha	—	45.5	118.5	145.0	247.0	82.5	146.5	11.0	796.0
Abbassiya ...	—	25.0	107.0	133.0	186.0	86.0	56.0	—	593.0

Temperatures C° (Kadugli)

		M. mx.	Range		M. min.	Range
Period Resting ...	Dec. 52-May 1953	37.8	41.9	32.8	20.0	26.1-16.7
Period Growth ...	June 53-Nov. 53	32.8	36.7	27.8	20.0	22.8-16.7

Heavy rains started early in July around the optimum sowing date causing severe waterlogging in low-lying areas. Here germination and growth were poor, necessitating much resowing. In consequence much of the crop was sown as late as August with the inevitable sequel of poor yields. By contrast the crop on the higher land got away to a good start and very good yields were obtained.

Damage by pests and diseases was generally slight and the commercial crop averaged 406 lbs. of seed cotton per acre over an estimated 162,966 acres.

Cotton Variety Trials

The standard variety trials were planted at Lagowa, Kadugli, Talodi and Hebeila on 4, 5, 7 and 9 July respectively. The layout was identical, 5 varieties repeated 7 times in randomized blocks. Plot size was 0.025 acres with spacing 90 x 90 cm. Yield figures are given in table 10.

Table 10.

Kordofan Variety Trials 1953 54

Yield of seed cotton and lint in lbs. per acre.

	Habeila			Talodi			Lagowa			Kadugli			Overall Mean		
	Seed Cotton	Lint	G.O.T.	Seed Cotton	Lint	G.O.T.	Seed Cotton	Lint	G.O.T.	Seed Cotton	Lint	G.O.T.	Seed Cotton	Lint	G.O.T.
BAR 7/8.1	533	176	33.0	683	228	33.4	412	134	32.5	1155	375	32.5	696	228	32.8
BAR 7/8.2	489	162	33.2	612	206	33.7	405	131	32.3	1090	352	32.3	649	213	32.9
BAR 7/3	574	177	30.9	518	161	31.1	379	115	30.3	942	286	30.4	603	185	30.7
BAR SP 84	451	134	29.7	519	152	29.4	356	102	28.6	882	254	28.8	552	160	29.1
PUMP SCHEME	532	156	29.4	586	168	28.6	339	97	28.5	1008	284	28.1	616	176	28.7
SE (mean)		11.3			13.0			6.5			20.8				
Difference P — 0.05		33			38			19			61				

For the second season in succession, BAR. 7/8.1 maintained its high yield. At all four sites it outyielded significantly BAR. SP 84 and overall lint figures indicated an increase over BAR.SP 84 and Pump Scheme Strain of 42% and 29% respectively. In every case it was superior in lint yield to BAR. 7/8.2 but not significantly so.

Combined yield and spinning test figures for the two seasons are worthy of note.

	lint.lbs./acre	%
BAR. 7/8.1	261	137
BAR.SP 84	191	100
Mean of 4 trials (8 replications) 1952/53 and 4 trials (7 replications) 1953/54		

	Effective length. (32 nds)	Standard Hair Weight	CxS (40's)	Yarn Appearance)
BAR.7/8.1	37	197	2043	5.2
BAR.SP 84	37	200	2139	5.0
Mean of 4 trials 1952/53.				

Variety trial figures (table 11) from Tozi and Yambio indicate its adaptability both to the dryer conditions of the central rainlands and to the wetter climate of Equatoria.

Table 11.

Tozi V.T. 1953/54 6x6 Latin Square (adjusted to stand)		Yambio V.T. 1953/54 (Randomized Block (6 replics.)		
	Lint (lbs/acre)		Lint (lbs/acre)	G.O.T.
BAR.7/8.1	481	BAR.7/8.1 ...	317	37.9
BAR.7/8.2	466	BAR.SP 84 ...	248	34.8
P 268F	460	BAR.11/5 ...	227	34.4
MU8b	415	S 47	225	33.9
BAR.SP 84	348			
P.S.S.	326			
Diff. (Maximum) 5% level =51 lbs.		S.E. (mean) = 11 Sign. difference 5% level = 33 lbs.		

A summary of performance of current strains in Kordofan variety trials (up to and including season 1953/54) and spinning test figures (up to and including season 1952/53) are shown in tables 12 and 13.

Table 12.

Summary of Performance of current Strains in Kordofan Variety Trials up to and including Season 1953-54.

	Seed Cotton (lb/acre)				Lint (lb/acre)			
	No. of Trials	Variety	P.S.S.	Variety as % of P.S.S.	No. of Trials	Variety	P.S.S.	Variety as % of P.S.S.
P.S.S.	67	930	930	100	58	268	268	100
BAR. SP 84	24	871	894	97	24	279	268	104

	Seed Cotton (lb./acre)				Lint (lb./acre)			
	No. of Trials	Variety	BAR SP 84	Variety as % of BAR SP84	No. of Trials	Variety	BAR SP 84	Variety as % of BAR SP84
BAR SP 84	28	984	984	100	28	314	314	100
BAR. 7/3	12	882	885	100	12	284	272	104
BAR. 7/8.1	8	775	641	121	8	261	191	137
BAR. 7/8.2	4	649	552	118	4	213	160	133
P.S.S.	24	894	871	103	24	269	279	96

Table 13.

Summary of Spinning Test Reports on Current Nuba Mountains Strains up to and including 1952-53.

Variety	Effective Length 32's			Standard Hair Weight			Corrected Lea-Count x Strength Product.								
		Mean			Mean			Means of 32's			Means of 40's			Means of 50's	
	No. of Trials	Variety	BAR SP 84	No. of Trials	Variety	BAR SP 84	No. of Trials	Variety	BAR SP 84	No. of Trials	Variety	BAR SP 84	No. of Trials	Variety	BAR SP 84
P.S.S. ...	21	37	38	21	194	195				21	2210	2154	11	2040	1968
BAR. 7/3	9	36	37	9	206	193	1	2179	2023	9	2010	2072	1	2020	2147
BAR. 7/8	10	36	37	10	195	194	1	1937	2023	10	2051	2184	1	2016	2142
BAR. 7/8.1	4	37	37	4	197	200	—	—	—	4	2043	2139	-	-	-

Appendix.

Key to Symbols used in this Report.

The use of full stops indicates the number of the ' filter ' *e.g.* BLR 14/25.

BLR. 14.25.1 1st filter

BLR. 14/25.2 2nd filter

Sakel Types

DS	Domains Sakel. Originally imported from Egypt but produced locally since 1936. Grown commercially in the Gezira.
BLR. 14 25	A Sakel type carrying B_2 and B_3 with fair leaf curl resistance.
BLJR. 14/29	A leaf curl resistant Sakel homozygous for B_2, B_3 and H_1.
Hairy Giza 36	Hairy barbadense type imported from Egypt

L Types

X1730A	The successor to X1730 and X1530 produced from Sakel selected for leaf curl resistance by Lambert. Grown commercially in Gezira, Gash and Tokar.
XAG	X1730A grown at the Gash Delta
XAT	„ „ „ „ Tokar
BAR. 1730L	7th backcross X1730A homozygous for B_2. 1st filter grown commercially throughout the White Nile Schemes and part of the Gezira (XL-1)
BAR. 4/16	An X1730A type carrying B_2 and B_3.
BAR. 5/6	An X1730A type carrying B_2, B_3 and the red arboreum pigment gene R_2 RS

BAR. SP 84	Uganda SP 84 homozygous for B_2 Grown commercially in Kordofan and Equatoria.
BAR. 7/8	BAR. SP 84 carrying B_2 and B_3.
BAR. NT96	A single plant selection from the cross '57 x Over-the-Top' carrying B_2.
BAR. 20/1	BAR NT96 selected for cluster characters.
Pump Scheme Strain	An old commercial bulk deriving from Nyasaland Upland and formerly grown commercially in Northern Province, Kordofan and Equatoria.
BAR. 12/9	From C (48) 4 Namulonge BP 52 stock made homozygous for B_2
XA129	A single plant selection from P.S.S.
BAR. 11/5	XA129 homozygous for B_2.
BAR. 11/6	,, ,, ,, B_3.
BAR. 11/7	,, ,, ,, B_2 and B_3.
BAR. 10/1 and 10/3	Deltapine types carrying B_2.
Clevewilt	An American (*hirsutum*) commercial type.
Hopi Acala	A very early type of high intrinsic fibre strength imported direct from the U.S.A.
Tanguis	of Peruvian origin.
Ferguson	A hairy American type from the Philippines via Trinidad.
MU8b	A Malwa Upland type from India.
Pubescent T 611	hirsutum type. Mutant in the F_3 of Trice x Tidewater hybrid.
Punjab 244 F	A Punjab commercial type (*hirsutum*)
Punjab 268 F	As above.
S 47	From Uganda
St. Ignatius	A hairy *marie-galante* type.
Stoneville 20	Imported from the Belgian Congo.
Wilds SUS 16/1	American long staple type. Grown commercially under irrigation in Northern Province.

ENTOMOLOGICAL SECTION.

by R. J. V. Joyce

I. Introduction.

The entomological staff in the Gezira was augmented by the transfer to Wad Medani of Lloyd Eff. George on promotion. He assisted the Government Entomologist in assessment of insect numbers in the commercial areas of cotton in Sudan Gezira. Mr. Pollard continued his investigations in the Gezira on the biology of the cotton fleabeetle and the cotton whitefly.

The Gezira spraying contract continued to evoke the interest of commercial firms, who were prepared to employ in the field considerably more research staff than were available to the Government Entomologist. It was fortunately possible to compile a programme of investigation of the effects of spraying in the Gezira agreeable to the commercial firms, the Sudan Gezira Board and the Government Entomologist. The analysis of these experiments has been a very big task and has been completed only during the 1954 55 season as a result of the appointment by the S.G.B. of Mr. Q. A. Geering. To coordinate all this work a Gezira Entomological Committee was formed under the chairmanship of the Chief of Research Division. The membership of the Committee included the S.G.B. and the Government Entomologist. Invitations to join the Committee were extended to and accepted by Pest Control (Sudan) Ltd., Imperial Chemical Industries (Sudan) Ltd. and Shell Chemicals (Middle East) Ltd. The duties of the Committee are to discuss pest problems and plan spraying experiments in the Gezira, these experiments being carried out under the direction of the Government Entomologist. The Committee held three meetings during the course of the season.

In the Gash delta investigation of the biology and control of cotton bollworms was continued by a team of entomologists led by J. P. Tunstall, seconded to Gash Board from Pest Control (Sudan) Ltd. and working under the direction of Government Entomologist.

Research into the economic importance and control of cotton stainers in the Nuba Mountains was continued by Mr. R. C. H. Sweeney who is seconded from Pest Control (Sudan) Ltd. to the Entomological Section, and works under the direction of the Government Entomologist.

The Sudan was invaded by locust swarms during May and June 1953 on a scale larger than in any other year of the present plague which began, as far as the Sudan is concerned, in 1950. This invasion followed the cessation of control activities by the British Desert Locust Control in north-central areas of the Arabian peninsula and might have been a result of it. The enlarged programme of investigations in the Gezira reduced the number of staff available for locust control. It was therefore decided to supplement the available ground organisation by an Air Spray Unit whose duties were to establish the pattern

of swarm invasion of the Sudan, so that the best distribution of available resources could be effected, and to spray any suitable swarms found in the course of reconnaissance. This general strategy was successful in that subsequent crop damage by locusts was negligible. The efficient use of aircraft was possible only through the generous help extended by the East African High Commission, who lent to the Sudan an experienced officer to take charge of the operation and the whole of its own Airspray Unit to work in the Sudan between May and July, and to assist a Sudan Flight of chartered aircraft.

The importance to the Sudan of locust control in the Arabian peninsula was recognised by the Government and the Sudan was represented at a Conference at Damascus called by the Food and Agricultural Organisation of the United Nations to plan international cooperation in locust control in this theatre. The Government Entomologist also attended two meetings of the Desert Locust Survey Advisory Committee.

Shortage of staff experienced in problems of grain storage has caused anxiety in view of the large quantity of Government grain for whose storage the Ministry of Agriculture is responsible. Observations, reduced, however, to a minimum, have continued on the experiments in grain storage at Juba.

The present report falls into the following sections. Only Sections II to V are presented here.

II.	General survey of pests of crops.	Field Laboratories and all reports received.
III.	Commercial Spraying experiments in Gezira and White Nile Schemes.	R. J. V. Joyce, Lloyd George, Q. A. Geering (S.G.B.), D. R Laurei, R. O. Bowley (Plant Protection Ltd.), I. E. Darter (I.C.I. (Sudan) Ltd.), T. A. Lister (Shell Chemicals M. E. Ltd.), M. R. Norman and R. Simons (Pest Control (Sudan) Ltd.).
IV.	Research in the Gezira	
	(a) Biology, status and control of the cotton fleabeetle	M. R. Norman.
	(b) Biology, status and control of the cotton whitefly	M. R. Norman, R. J. V. Joyce and D. G. Pollard.
	(c) Laboratory evaluation of insecticides against whitefly	M. R. Norman.
	(d) Biology of cotton thrips.	R. O. Bowley.

V.	Investigation of Spraying Technique.	R. C. Amsden (Pest Control (Sudan) Ltd.) and R. J. V. Joyce.
VI.	Research in Tokar Delta	A. T. Goodman.
VII.	Research in Gash Delta	J. P. Tunstall and E. Dennis.
VIII.	Central Rainlands Research Station.	W. S. Richards (see C.R.R.S. Annual Report).
IX.	Yambio Research Farm	E. M. McDermid (see Yambio Experimental Farm Annual Report).
X.	Research in Nuba Mountains	R. C. H. Sweeney.
XI.	Grain Storage	H. S. Darling (University College of Khartoum) and R. J. V. Joyce.
XII.	Desert Locust Research	
	(a) Survey	H. J. Morris
	(b) Control	Beshir Babiker el Shafie and Awad Mustafa.
XIII.	Desert locust control	R. J. V. Joyce and Beshir Babiker el Shafie.
XIV.	Control of pests	Beshir Babiker el Shafie and Gaafar Yahia.
XV.	Plant quarantine service	Ahmed Mohammed Mekkawi.
XVI.	Publications.	

II. General Survey of Insect Pests of Crops in the Sudan.

1953/54.

Cotton Pests

Bollworms (Various spp.) *Lepidoptera.*

Blue Nile Province

(a) Gezira Scheme (see Appendix I).

The pink bollworm. *Platyedra gossypiella* Saund (Gelechiidae) caused light damage to cotton. Its incidence was the lowest since records began in the 1937/38 season This is particularly surprising because the enforcement of the dead season for bamia (*Hibiscus esculentus* L. : Malvaceae), was known to have been poor within the Gezira Scheme and was in fact held responsible for the high incidence of leaf-curl in the Domains Sakel of the northern Gezira. The number of bolls present per feddan was 50% greater than recorded bythe same sampling method as used during the previous season. (tables 1 and 2).

Table 1.

The sum of the average monthly total of bolls per feddan damaged by *P. gossypiella* during the past 17 years (in thousands per feddan).

Season	Total	Season	Total	Season	Total
1937/38	43.7	1943/44	16.5	1949/50	22.0
38/39	40.5	44/45	12.2	50/51	15.4
39/40	23.1	45/46	10.2	51/52	5.7
40/41	38.3	46/47	9.8	52/53	19.8
41/42	8.9	47/48	25.8	53/54	3.3
42/43	46.3	48/49	17.0		

The incidence of the Egyptian bollworm *Earias insulana* Boisd. (Noctuidae) in mature bolls in Gezira Scheme was the same as during the previous season and was light. The sum of the average monthly total of bolls per feddan damaged by this moth was 4.6% (table 2).

Table 2.

The sum of the average monthly total of bolls per feddan damaged by bollworms and expressed as a percentage of total production of mature bolls over 4 seasons

(in thousands per feddan)

	1950/51	1951/52	1952/53	1953/54
Total bolls per feddan	638.4	348.5	520.8	787.3
Total bolls damaged by P.B.W.	15.4	5.7	19.8	3.3
Total bolls damaged by E.B.W.	3.9	3.6	4.7	4.6
% crop damaged by P.B.W. ...	2.4	1.3	3.8	0.4
% crop damaged by E.B.W. ...	0.6	1.0	0.9	0.6

In table 2 the percentage loss of crop in the Gezira as a whole is estimated by expressing the sum of the average monthly total of bolls per feddan damaged by *P. gossypiella* and *E. insulana* as a percentage of the sum of the average monthly total of bolls per feddan. It will be seen that during the present season the estimated damage to crop by these two bollworms was 1.0% as compared with 4.7% during the previous season.

The American bollworm *Heliothis armigera* Hamp. (Noctuidae) caused appreciable damage during November and December to buds and young cotton bolls and occasionally to the growing points of the plants at all localities examined in the Gezira Scheme. Shedding was reported to have been particularly severe in Hag Abdalla and some other areas of the South Group. In Saadalla serious damage occurred on July-sown BAR XLI cotton sprayed with parathion. During January and February few larvae of *Heliothis* were found and damage to mature bolls was negligible.

White Nile Schemes

Samples of green bolls were taken during November, December, January and February from Hashaba and Fatisa Schemes. The results of the analysis of these samples for bollworm infestation are summarised in table 3 where the loss of crop from bollworm was estimated from the percentage of damaged bolls which were found in the total of the average monthly numbers of mature bolls per feddan.

Table 3.

Incidence of bollworms on the White Nile Schemes, Hashaba and Fatisa, during the season 1953 54 expressed as the sum of the average monthly total of bolls per feddan damaged by bollworm.

(in thousands per feddan)

Details	Hashaba	Fatisa	Mean 1953/54	Mean 1952/53
Bolls per feddan	547	549	548	204
Bolls damaged by *P. gossypiella*	10	15	12.5	19
Bolls damaged by *E. insulana* ...	16	16	16.0	4
% of crop damaged by *P. gossypiella*	1.8	2.7	2.3	9.3
% of crop damaged by *E. insulana*	3.0	2.9	2.9	2.0
% of crop damaged by bollworm	4.8	5.6	5.2	11.3

Bollworm damage was less than during 1952/53, but greater on these schemes than in the Gezira.

Northern Province

In Shendi area the initial infestation of *Platyedra* to cotton bolls was much heavier this season than during the previous season. In July and August damage was severe on young bolls and was associated with extensive fruit shedding particularly in Fadlab and Buatid Schemes. The peak of infestation was reached in October when 69% of mature bolls were damaged compared with 51.5% for the same period last year.

In Dongola area, *Platyedra* infestation of mature bolls was lighter than in Shendi, ranging between 4% and 42% in the various cotton areas during October and November.

The incidence of *Earias insulana* was remarkably light in Shendi District in most areas during July, August and September. In October and November the infestation slightly increased and was fairly heavy in a few localities.

In Dongola area *Earias* was heavy in the southern schemes and much lighter in the north.

Heliothis and *Diparopsis* were not recorded in cotton in Northern Province, although the former pest was present in small numbers on most other host plants in October and November.

The emergence of *Platyedra* from a sample of 10,000 mature cotton bolls collected at the end of each of the past six cotton seasons from Zeidab Scheme is summarised in table 4. The great majority of moths emerged during November and December in less than one month after entering the pupal stage.

Table 4.

Emergence of *P. gossypiella* from 10,000 cotton bolls collected in November of each year in Shendi District.

Period.	49/50	50/51	51/52	52/53	53/54	Total	Mean	%
November ...	—	3,229	—	—	303	3,532	706.4	17.7
December ...	6,764	323	5,834	910	719	14,550	2,910.0	72.8
January ...	557	82	408	92	15	1,154	230.8	5.7
February ...	13	76	4	35	9	137	27.4	0.7
March ...	21	24	5	29	7	86	17.2	0.4
April ...	26	20	—	—	8	54	10.8	0.2
May ...	6	4	2	8	—	20	4.0	0.1
June ...	—	—	—	1	—	1	0.2	0.0
July ...	10	—	—	268	18	296	59.2	1.5
August ...	7	—	—	102	9	118	23.6	0.6
September ...	—	—	—	—	—	—	—	0.0
October ...	1	1	—	53	—	55	11.0	0.3
Total ...	7,405	3,759	6,253	1,498	1,088	20,003	4,000.6	100.0

Khartoum Province

Nothing to report.

Kassala Province

(a) Gash Delta.

The incidence of *P. gossypiella* in the Gash was far greater than during the previous season The pest first appeared in January and then was observed in ever increasing numbers in mature bolls until by April it was more common even than *Diparopsis*. It was particularly evident in the three northern stations and in March a bollworm count showed 19 6% of the green bolls at Tendelai were infested by pink bollworm larvae.

Sudan bollworm *Diparopsis watersi*, Roths(1). A small emergence of moths was observed in July. In August emergence increased and eggs were first observed on ratoon cotton on 26th August. Damage to the crop commenced in September and continued during the remainder of the season. From January onwards severe parasitism of mature larvae, as high as 20% in some areas in February, was recorded. However, the very poor crop was largely attributed by the Gash Management to the ravages of the Sudan bollworm which, by attacking fruits early in the season, delayed picking and thus lowered the grade, (which was exceptionally bad) and also by extending the fruiting season, rendered the crop more liable to damage by pink bollworm.

(1) Previous to 1951 this species was known as *D. castanea* Hamp. The genus, was revised by Clements (1951) who showed that *castanea* was restricted to south of the Equator. The Sudan species was identified as *D. perditor*, Clem but it has now been shown that an earlier name *D. watersi* Roths., exists for this species.

Earias was first noticed in small numbers in October. Spraying campaigns directed against the most important dead season host plant "hambuk" (*Abutilon* sp.) were carried out with "Phordester", a proprietory hormone weed killer, at Hadaliya and Metateib. Results assessed by plant destruction were sufficiently encouraging for a further campaign in May and June to be conducted at Hadaliya, Metateib and part of Tendelai. *Earias* was still observed in January 1954 on cotton at these stations. It has not yet been possible to assess the value of *Abutilon* destruction. A survey carried out in January in these stations revealed an infestation of 12.4% of mature bolls which was bad enough but overshadowed by the damage by Sudan bollworm.

Heliothis armigera was first recorded on cotton in October and throughout the season occasionally damaged buds, flowers and smal bolls.

(b) Tokar Delta.

No survey of the incidence of bollworms was carried out in Tokar delta but the incidence of all bollworms in the mature bolls was low. *Heliothis* and *Earias* were present in small numbers and no serious damage to the cotton crop was reported. Small numbers of *Platyedra* were observed at the end of the season.

Observations were continued on the date of emergence of *Platyedra* from resting larvae and the results are summarised in table 5 where the emergence of larvae produced in Tokar is compared with that of larvae from Gash, both under Red Sea littoral conditions.

Table 5.

Emergence of adults of *Platyedra gossypiella* at Port Sudan from samples of bolls collected from Tokar and Gash deltas during 3 seasons.

(Numbers per 10,000 bolls)

Month of Emergence.	Month of sampling.			Tokar bolls means of 3 seasons	Gash bolls means of 3 seasons.
	1952	1953	1954		
June ...	0	0	154	9.1	95.3
July ...	178	9	70	61.3	108.0
August ...	41	1	3	14.0	12.0
September	31	6	84	26.0	78.7
October ...	35	1	18	12.0	18.7
November ...	2	0	0	0.3	0.0
December ...	1	0	0	0.2	0.0
Total ...	288	17	329	122.9	312.7

Kordofan Province.

(a) Nuba Mountains.

P. gossypiella was of no importance on the cotton crop during the current season and its incidence was far less than during the previous season. Some light damage by *E. insulana* was recorded in certain localities but for short periods. Only *Diparopsis* was widely distributed, causing serious shedding of immature fruit and damage to mature bolls. *Heliothis armigera* was occasionally found on cotton in all areas.

(b) Abu Habl Scheme.

No serious bollworm damage was reported on cotton although the presence of all 4 species was reported.

Equatoria Province

The pink bollworm was common in all cotton growing areas in Equatoria Province from August and peak numbers were reached in December and January. In Yambio attack was very heavy. The percentage infestation revealed by examination of bolls picked from the plants was much higher than that in shed collections, the average infestation in the crop reaching 47%, whereas it was only 10% in the shed bolls. *Platyedra* was also found in ripe fruit of *Hibiscus esculentus* L. and *H. sabdariffa* L. At Maridi and Ezo the situation was slightly better. The populations of *Earias insulana* and *Helicthis armigera* on cotton at the Yambio Research Farm were small throughout the season and were only responsible for insignificant damage of the buds and bolls.

Central Rainlands

All 4 species were recorded but damage was light (*cf.* 1952). Samples taken in October and a survey after harvest in two fields provided information on the severity but were inadequate to gauge the effect on yield of bollworm damage. There was a smaller yield from the later planting date and this was associated with far heavier shedding. The attack by bollworm, 13-14%, was similar at both planting dates and cannot account for the difference in yields.

Cotton Thrips *Hercothrips* spp. (Thysanoptera: Thripidae)

In the Gezira Scheme, *Hercothrips fumipennis* Bagn. and Cam appeared on cotton during the first half of October, but the attack was light. The infestation remained light in the south west and the north but was heavier in Tayiba (Centre Group) and in the South Group. *H. sudanensis* was observed only on unsprayed cotton during November. Both species were kept under control by the routine spraying with DDT. In the White Nile Schemes the incidence of thrips was light except at Um Gerr where they caused slight damage.

In the Gash neither species caused any serious damage to cotton. In Tokar delta thrips were observed in small numbers but were of no importance.

In Kordofan Province thrips were numerous at Abu Habl Scheme and the cotton crop suffered greatly from October to December. More than 1062 feddans were sprayed with DDT against this pest by the cultivators with hand pumps borrowed from the Entomological Section. In the Nuba Mountains thrips were not recorded as a pest. At Tozi Research Farm *Hercothrips* spp. were again rarely recorded damaging cotton.

COTTON WHITEFLY *Bemisia tabaci* Gen. (Hemiptera : Aleurodidae).

Whitefly were a serious pest in the Gezira Scheme but their incidence is considered to have been less than during the previous two seasons. The infestation, which was obvious in September, rapidly increased and reached a peak in mid-November. Heavy asal (honey dew) was apparent in some areas during November and December. Sprayed cotton had generally a heavier whitefly infestation throughout the Gezira than unsprayed cotton. On the White Nile Schemes whitefly were present on all schemes. The heaviest incidence recorded was at Um Gerr but the greatest asal at Wakara Scheme where it was severe and universal. In Abdel Magid Scheme whitefly were numerous and associated with serious asal in several areas. In Gash and Tokar deltas whitefly were unimportant. In Central Rainlands whitefly were not recorded as a pest of cotton, in contrast with 1952.

COTTON JASSID *Empoasca libyca* de Berg. (Hemiptera : Jassidae).

Counts in late September on cotton of large scale experiments in the commercial area suggested that initial infestation in the Southern Gezira was considerably greater than during the previous 2 seasons and comparable with that of 1950/51. Peak infestations in unsprayed cotton of experiments were reached in mid-November in South Group and at the end of November in North Group. Infestations in the two extremities ranged from 70-150 and 300-400 nymphs per 100 leaves in South and North Groups respectively. These figures are similar to those recorded during the previous 2 seasons, but in excess of those of 1950 51 season.

Damage to unsprayed cotton was conspicuous in November and December and more severe on Domains Sakel than on X1730A. Over 98% of the cotton of the Sudan Gezira Board or 229,575.5 feddans were sprayed between 23 September and the end of October. Reinfestation after spraying was slight and jassid damage very rare.

The results recorded in the sprayed and unsprayed comparison Numbers (90 feddan fields) which occur in most Blocks of the Sudan Gezira Board are given in table 6, where the results of 6 seasons are listed.

Table 6.

Increase in yield of sprayed over unsprayed comparison Numbers of 90 feddans for 6 seasons.

Sudan Gezira Board.

(in k.p.f.)

GROUP	1948/49	1949/50	1950/51	1951/52	1952/53	1953/54	Mean
South	—	—	-0.23 (6)	1.64 (5)	0.06 (7)	0.39 (5)	0.465
Centre ...	—	1.39 (4)	-0.27 (4)	0.68 (6)	0.62(10)	-0.11 (9)	0.442
Messellemiya ...	—	0.92 (5)	0.95 (7)	0.96 (6)	1.22 (8)	0.74 (9)	0.958
West	0.29 (5)	2.50 (5)	0.21 (5)	0.80 (2)	0.90 (8)	1.01 (5)	0.952
North	1.72(11)	2.11 (1)	1.70 (5)	1.07 (4)	1.00 (6)	1.25(10)	1.476
Whole	0.71(16)	1.73(15)	0.47(27)	1.01(23)	0.76(39)	0.66(38)	0.89
S.E. ... ... (treat mean)	—	0.251	0.267	0.123	0.143	0.170	
Least sig. ... diff. (P=0.05)	—	1.13	1.048	0.393	0.561	0.668	

NOTE : (i) — represents no experiment (or calculations) carried out.

(ii) Numbers in brackets represent the number of comparisons.

The value of these figures is uncertain because doubt has been cast on the validity of the assumption that the unsprayed number is selected at random. Moreover it is possible that the yield of a single unsprayed 90 feddans cotton Number in a sprayed Block, where unsprayed cotton represents only 1.5% of the total area of cotton, may have been reduced by the spraying in the vicinity.

No general surveys were carried out in the White Nile Schemes. At Abdel Magid, jassids were reported lighter than usual. Infestations were heavier on pump schemes on the White Nile. Nearly all this cotton was sprayed with DDT and reinfestation during November and December caused inconspicuous damage.

In Gash and Tokar deltas jassids were light and regarded as unimportant.

In Northern Province jassids were present in the crop in moderate numbers in Shendi District from June to August causing visible damage to leaves. Throughout October they were very severe on cotton particularly in Zeidab and Fadlab Schemes, where serious shedding of leaves was attributed to this pest. In Dongola area the infestation was heavy and very severe damage was caused to leaves during August and September, particularly in the early sown cotton.

In Equatoria Province jassids (*Empoasca* spp.) were present on the cotton crop but their incidence was low.

In the Central Rainlands jassids were very few and caused no damage, the cotton BAR 7/8.1 being regarded as jassid resistant.

Cotton Aphis *Aphis gossypii* Glov. (Hemiptera : Aphididae)

Cotton aphis was recorded in all cotton growing areas but was seldom a serious pest. In the Gezira Scheme aphis infestation on cotton was in general heavier than it was during the previous season, and in some localities was responsible for considerable asal in November and December. Once again in the White Nile Schemes, particularly those south of Kosti, nearly all of which was sprayed with DDT, aphis were a serious pest in November and December. In the Central Rainlands no damage was caused by aphis. In Equatoria Province aphis was reported to have attacked cotton in the cotyledon stage and caused slight damage. In Northern Province cotton aphis was not recorded as a pest.

Cotton Stainers *Dysdercus* spp. (Hemiptera : Pyrrhocoridae)

Nuba Mountains (see also Section X).

In 1952 53 season *Dysdercus superstitiosus* F. was the dominant species of stainer until late in the season. In 1953/54 season, *D. fasciatus* Sign. was dominant and observations refer largely to this species. *D. superstitiosus* was recorded in several places early in the season (May-April) but neither species was common until the end of June when *fasciatus* began to become more conspicuous everywhere. By July *fasciatus* had established its predominance in all areas examined except in the ginnery compound and gardens at Kadugli where *superstitiosus* was more numerous. Numbers were similar in August but

in September *fasciatus* increased on Tebeldi trees, *Adansonia digitata* L. (Bombacacae) and *superstitiosus* remained rare. By November *fasciatus* had become very widely distributed, and at the end of the month and during December between 30% and 40% of the Tebeldi trees in some districts were infested, many severely. In later months (January-March) only *fasciatus* was seen. Numbers decreased in March and April.

In the Abu Habl Scheme *Dysdercus* was found in appreciable numbers in the cotton growing round the ginning factories, stores and seed-pits. The bugs were at first sprayed with paraffin and later with DDT emulsifiable concentrate with a great deal of success.

Equatoria Province.

D. superstitiosus F. was by far the most abundant species. *D. nigrofasciatus* Stal. and *D. melanoderes* Karesh. were more common than usual during September and October. *D. melanoderes* is normally rare and it is thought that the 1952/53 dry season which was abnormally wet, may have been particularly favourable to this species. Specimens of *D. haemorrhoidalis* Sign and *D. cardinalis* Grst. were captured in the crop in early October and a specimen near to *D. nigrescens* was also taken at about the same time. At the end of November adult *Dysdercus* began to move to *Sterculia tomentosa* Guil. and Perr. (Sterculiaceae) and the populations on cotton remained predominantly nymphal until plant destruction at the end of the season.

COTTON CAPSIDS (Hemiptera : Capsidae)

Helopeltis spp.

In Equatoria Province *H. schoutedeni*, Reut. was present in small numbers on the cotton crop from the cotyledon stage (late June). The periods of peak population were mid-August, when feeding was on young green leaves, and late September when feeding was largely on green bolls. During November the insect was found with difficulty. Infestation was only heavy locally and was generally unimportant. Specimens of *H. proxrubrinervis*, Poppius. were also collected on cotton.

Creontiades pallidus, Ramb.

In Northern Province this capsid was recorded on Wilds SUS cotton at Zeidab Scheme towards the end of June but damage was considered negligible. In July up to mid-August the infestation was very heavy on cotton and a great number of buds, flowers and young bolls marked by the yellow stain typical of *Creontiades* puncturing were shed. In September and October the pest rapidly decreased on cotton.

In Tokar delta *C. pallidus* was abundant on cotton during November and December and its occurrence was associated with much shedding of buds. The effects of this insect are discussed in Section VI.

Campyloma nicolasi, Reut. and Put.

This bug continued to be recorded in Northern Province but was of no apparent economical importance.

Cotton Fleabeetle *Podagrica puncticollis* Wse. (Coleoptera: Halticidae)

In the Gezira Scheme the attack was light on the seedling cotton in the early sown areas *e g.* Remeitab, Abdel Hakam and Wad Saadalla with a slightly heavier infestations in other Blocks in the South, Centre and Messellemiya Groups. No important damage occurred.

In the Central Rainlands the same species was present in very small numbers and did not cause any appreciable damage. In Northern Province *Podagrica* was first seen on cotton seedlings early in June in both Shendi and Berber areas. In July it was very common in all cotton areas and was much heavier in Fadlab and Baulid of Shendi district. Between August and October numbers were light. In Dongola area the infestation was even lighter than in Shendi district.

In the Nuba Mountains *Podagrica* was very common early in the season (April and May) on its numerous wild hosts and particularly on cultivated *Hibiscus esculentus, Corchorus olitorius* L., wild *Hibiscus* and several other plants grown in irrigated gardens and near khors, and particularly on cotton left over from the previous season. Later in June vast numbers bred on the cotton growing in the Kadugli compound, where cotton seed left over from the previous season had germinated and by this time had covered most of the compound area with young seedling plants. No serious damage to the crop was reported in any district.

Termites (*Isoptera*).

Termites were responsible for some loss in seedling stand of cotton in the Gezira and White Nile Schemes, but only in experimental cotton were control measures considered necessary. Wilting of more mature plants in November and December, often associated with termite attack, was less common in the Gezira than during the two previous seasons. It was, however, devastating amongst some varieties of American cotton especially Hopi Acala and Punjab 268F grown under irrigation in the southern Gezira. It is doubtful if this wilting can be attributed to primary termite attack. In Tokar delta termites attacked and destroyed mature plants and were again held responsible for a considerable loss of crop. In the Nuba Mountains and Gash delta primary termite attack was recorded, but was considered unimportant.

Amongst the genera recorded attacking cotton were *Odontotermes, Ancistrotermes, Microtermes* and *Amitermes*.

Cotton Stemborer *Sphenoptera gossypii* Cotes. (Coleoptera: Buprestidae).

This pest was again recorded on cotton in the Gezira and White Nile Schemes but was not regarded as of any economic importance. In the Gash delta infestations were similar to those recorded in other seasons and remained at a consistently high level. When caged plants were attacked a very considerable reduction in growth and fruit production was recorded. In the Nuba Mountains this species was wide-spread but less common than in 1952 53 season, being found infrequently during December and January.

Cotton Leaf Roller *Sylepta derogata* F. (Lepidoptera : Pyralidae)

This pest was recorded only from the Nuba Mountains during 1953/54 where it was occasionally responsible for very severe, but very localised damage, complete defoliation of areas of up to 20 feddans having been recorded. As in previous seasons larvae were first noted on cotton in August and peak numbers were reached in October. Larvae were also recorded on *Hibiscus esculentus*, *H. cannabinus* and *H. dongolensis* during August and September, and on *Grewia* spp. (chiefly *G. villosa* Willd : Tiliaceae) during November and December. A high degree of parasitism of larvae from cotton was found, a maximum of 89% parasitised larvae having been collected from one field. The most common was *Microbracon* spp. (Hymenoptera : Braconidae). but the material awaits identification.

Other Pests

In the Gezira *Prodenia litura* L. (Lepidoptera : Noctuidae) was again recorded defoliating cotton plants in areas south of the G.R.F. Although the attack was quite unimportant and there was no damage on the scale which occurred in 1952/53, its appearance for a second season is of interest. This species was also reported from the Nuba Mountains where it was found in unimportant numbers.

Grasshoppers were unimportant in the Gezira, although some very local damage occurred during September and October and particularly in November where leaves were reduced to skeletons by nymphs of *Pyrgomorpha cognata* Kr. In the Gash delta, especially in the northern stations, grasshopper damage was very severe over wide areas. This followed exceptionally heavy rains which must have favoured breeding and serious invasion of cotton occurred from the weeds as the fallows dried off. The most numerous were *Pyrgomorpha cognata* whose nymphs, which bred within the crop, skeletonised leaves in a typical manner. Perhaps more severe damage was caused by adults of *Catantops axillaris* Thunb. which commonly bit through the main-stem or leaf petiole severing, or partially severing, growing points and leaves. The same habit was also observed in *Caloptenopsis insignis* Walk. *Oedaleus johnstoni* Uv. was also very numerous and was observed eating cotton leaves. Defoliation of cotton by grasshoppers (both *Acrididae* and *Tettigonidae*) was reported to have been appreciable in the Nuba Mountains during the season.

The cricket *Liogryllus bimaculatus* de Geer (Orthoptera : Gryllidae) was again reported only from the Gash delta damaging young cotton.

Amongst the Coleoptera the larvae of *Schizonycha* sp. (Melolonthidae) was again reported from several Blocks in Messellemiya Group of the Gezira destroying young cotton plants. It was also recorded in the Nuba Mountains and Gash delta where its damage may be important. In the Gash *Adesmia miliaris* Rehe (*Tenebrionidae*) again attacked stems of cotton afterwards destroying the plants. In the Nuba Mountains *Mylabris* spp. (Meloidae) (7 species recorded) caused severe damage to cotton flowers destroying up to 50% in a single field. Several Cetonid beetles, of which the commonest was *Diplognatha gagates* Forst. also attacked flowers as did *Apion* spp. (Curculionidae).

The seed bug *Oxycarenus hyalinipennis* C. (Hemiptera : Lygaeidae) was common in Gash and Tokar deltas and in the Nuba Mountains may have been responsible for some of the staining of lint in open bolls.

Among ants (Hymenoptera : Formicidae) *Camponotus* spp. (especially *C. sericus* Fabr. and *C. rufoglaucus* Jerd.) *Monomorium* spp. and *Plagiolepsis* were observed attacking flowers in the Nuba Mountains and also buds and growing points. They appear sometimes to do a considerable amount of damage. *Tetramorium* spp. and *Monomorium* spp. also attacked cotton seed in the ground, in particular the radicle and hypocotyl of the germinating seed. In addition *Tetramorium* spp., *Camponotus* spp., *Anoplolepis* spp. and *Cremastogaster* spp. were observed tending aphis colonies on cotton plants.

Millipedes (*Diplopoda*) were again responsible for severe damage to young cotton throughout the Nuba Mountains. The taxonomy of this order has been little studied and it has not been possible to allocate even generic names to the material. At least 8 species are considered to be present. Numbers can be very great, for example in a 20 mile traverse (between Kosti and Tendelti) a mean population of 10 per yard was estimated in July 1954. This, however, consisted almost entirely of a single, carnivorous species, which has not been observed to feed on plants. Amongst phytophagous species populations of several thousands per feddan have been estimated. During the present season two species attacked cotton throughout its growth and at least three species attacked seeds and seedling cotton. Seeds were attacked in the soil and seedlings were damaged in the hypocotyl and the radicle. These attacks necessitated the resowing of large areas in several localities. When older plants were attacked death frequently resulted through subsequent entry by termites. Millipedes were first observed in May after the first rains, and peak populations were reached between July and late September. In November they were rare, having entered the soil for hibernation (and aestivation). During August 1953 and July 1954 migrations were observed consisting of a few hundred to several thousands individuals.

Pests of Dura (*Sorghum vulgare* Stapf.)

In spite of a large scale invasion of the Sudan by desert locusts, *Schistocerca gregaria* Forsk. and breeding on a considerable scale, there was no appreciable crop damage by this pest during the whole of the season 1953/54.

The grasshopper *Aiolopus savignyi* Kr. was numerous during July and August and destroyed seedling dura in the Gezira Scheme, Managil and Dueim areas; and in the Gedaref district. During September and October swarms of a considerable size were recorded in the Gezira but did not cause serious losses. Extensive breeding was reported from the Butana and in October the dura areas of the Gedaref district were invaded on a considerable scale. Extensive use of locust bait was reported to have prevented serious crop loss. At Tozi Research Station considerable local damage to dura from swarms of this grasshopper occurred.

The season was also favourable for the Acrididae *Oedaleus johnstoni* Uv. *Acrotylus blondeli* Sauss. and *Stenchippus mundus* Walk. which occurred in very large numbers in the Gezira and Gash delta but apparently caused little damage to any crop.

The Cockchafer grub *Schizonycha* spp. was responsible for important losses in stand of dura at the G.R.F. and occurred throughout the Gezira Scheme. In the Nuba Mountains it was an important pest of dura. The adult was numerous throughout the rains and was observed feeding on the leaves of *Hibiscus esculentus* and *Grewia villosa*.

The Dura Stemborer was important only in Northern Province. In the Shendi District a mean infestation of 11% of the stalks examined was recorded in controlled and uncontrolled areas In Dongola district incidence was far heavier, the percentage of infested stalks recorded in surveys being 33, 60 and 61 for November, December and January respectively. In the Berber area 65% of the stalks were found damaged and 95 larvae were found in every 100 stalks. In the Nuba Mountains this species is reported to have caused considerable local damage. The species was not recorded at all at Tozi Research station.

Heliothis armigera was not reported in serious numbers anywhere in the Sudan. It was most noted in Tokar delta. *Sitotroga cerealella* Ol. (Lepidoptera : Gelechidae) was commonly found throughout the Nuba Mountains, both the larvae and imago being found within the dura head. *Laphygma exempta* Walk. (Lepidoptera : Noctuidae) was found widely distributed in the western Jebels feeding in the heads of dura. *Omophorus stomachosus* Boh. (Coleoptera : Curculionidae) was also recorded occasionally in dura in the Nuba Mountains.

No reports of losses of seedlings stands from *Atherigona* spp. (Diptera : Anthomyidae) were received during the season although damage was recorded at the G.R F. The season was not favourable for the midge *Contarinia sorghicola* Coq. (Diptera : Cecidomyidae) in the Gezira, but at Tozi severe losses occurred to crops which came into flower during the 3rd week in October.

The dura andat *Agonoscelis versicolor* F. (Hemiptera : Pentatomidae) caused no serious damage during the season. *Aphis sorghi* Theob. (Hemiptera : Aphididae) was common in the Gezira especially in October giving rise to vast quantities of honey-dew on late maturing varieties. Infestation was very severe in Berber and Dongola districts, but in the controlled areas of Shendi the pest was not numerous at any time during the season.

Only in the Gash delta did the weaver bird (*Quelea quelea aethiopica* Sume) cause serious losses to grain.

Pests of Various Crops

Grain Crops

Dukhn (*Pennisetum typhoideum* Stapf and Hubb.) did not suffer any serious damage from pests during the season, but the following insects were recorded in Kordofan. *Anoplecnemis curripes* F. (Hemiptera : Coreidae) *Aphanus littoralis* Dist. and *A. apicalis* Dalb. (Hemiptera : Lygaeidae) *Mylabris farquharsoni*. Blair (Coleoptera : Meloidae) and *Rhyniptia reflexa* Burm. (Coleoptera : Rutelidae).

In Northern Province an unidentified stemborer was reported on wheat.

Rice grown in Malakal was attacked by *Pachydiplosis oryzae* (Diptera : Cecidomyidae). This is the first record of this pest in Sudan and the second in Africa.

Pests of Pulses and Fodder Crops.

In Northern Province whitefly, *Bemisia tabaci*, was particularly numerous on Egyptian beans (*Vicia faba* Linn) and lubia (*Dolichos lablab* Linn). On berseem (*Trifolium alexandrinum* Linn) *Creontiades pallidus*, *Colias marnoana* Rog. (Lepidoptera : Pieridea), *Laphygma exigua* and *Therioapyis ononides* Kolt. (Hemiptera : Aphid.dae) caused notable damage.

In the Gezira, attack on lubia by *Schizonycha* was very light in contrast with the serious losses caused by this pest for the last 4 years. Heavy whitefly occurred in some areas, but generally lubia throughout the Gezira was remarkably free from pest infestation.

In the Nuba Mountains lubia was eaten by *Epilachna chrysomelina* F. (Col. Coccinellidae), *Mylabris tristis* Rche, *Barombia humeralis* Lab., *Rhapidopalpa foveicollis* Luc. (Coleoptera : Galerucidae) and *Ootheca mutabilis* Sahlb. Ads. (*Cajanus indicus* Spreng) was often severely attacked by various species of *Mylabris*.

Pests of Oil Seeds

Simsim, (*Sesame indicum* Linn. Bignoniaceae) in Kordofan again suffered severe damage in the seedling stage from millipedes. Local damage by *Agonoscelis versicolor* was occasionally severe. *Aphanus litteralis* was wide-spread and caused severe damage to seeds after harvesting of the crop. *A. apicalis* was also recorded on simsim. Some serious but localised damage by the web-worm *Antigastra catalaunalis* Dup. (Lepidoptera : Pyralidae) occurred and this pest was probably the most serious one in the Nuba Mountains. At Tozi the web-worm was a serious pest of indehiscent varieties.

Ground nuts (*Arachis hypogaea* Linn. Papilionaceae) in Kordofan, were attacked in the seedling stage by millipedes. Leaves were eaten by *Monopelta dahlmani* Jac. *M. duplicata*, Sahlb. (Coleoptera : Galerucidae), *Asbecesta cyanipennis*, Har. *Barombia humeralis* Lab. *Rhaphidopalpa foveicollis*, *Ootheca mutabilis*, Sahlb. and *Luperodes* spp. (Coleoptera : Galerucidea). In the Central Rainlands only *Hercothrips fumipennis* was recorded attacking the leaves. This pest was not recorded in the Nuba Mountains. In all areas termites were responsible for serious losses in stand and yield. The species involved in Kordofan are *Odontotermes* spp., *Microtermes* spp. and *Ancistrotermes* spp.

Castor (*Ricinus communis* L.) in the Gezira suffered severe defoliation by *Pyrgomorpha cognata*. Fruits were occasionally damaged by *Heliothis armigera*.

Pests of Fibres

Experimental plots of Deccan Hemp (*Hibiscus cannabinus* L.) (Kenaf) at the G.R.F. were severely attacked by *Podagrica puncticollis* throughout the season. Sunn Hemp, (*Crotalaria juncea* L Mimosaceae) was severely attacked by the larvae of *Utetheisa pulchella* L. (Lepidoptera : Arctiidae).

The sweet water melon, (*Citrullus vulgaris* Chrad. Cucurbitaceae) in Kordofan was damaged by *Aspongopus viduatus* F. (Hemiptera : Pentatomidae) but less seriously than in the Nile valley. A serious pest of water melons was *Dacus vertebratus* Bezzi and *D. longistylus* Wd. (Diptera : Trypaneidae).

Pests of Fruit

In Northern Province the fruit-fly *Pardalaspis quinaria* Bezzi (Diptera : Trypaneidae) seriously damaged fruits of guava *Psidium guajava* L. throughout the year in Shendi District, being particularly severe between May and July. Citrus was also seriously damaged during September and October. Routine control measures have now been adopted in this area. This consists of collecting, crushing and burying all infested guava fruit throughout the year, and spraying citrus trees during September and October with sodium fluosilicate. During the season a total of 1700 trees were treated.

Mango seedlings were attacked by the scale *Lepidosaphes beechii* Bez. An outbreak of *Ferrisia virgata*, Ckll. (Homoptera : Coccidae) on guava occurred in the Shendi area and infested parts were pruned and burnt in accordance with local laws. *Tetranychus simplex* Herst (Acarina) were recorded on 1700 citrus trees in Shendi District. These were sprayed with water.

In the Nuba Mountains ripe fruit of mango (*Mangifera indica* L.) was attacked by *Sinoxylon sudanicum* Lesne. (Coleoptera : Bostrychidae). *Monolepta dahlmani* and *M duplicata* were recorded eating leaves. The weevil *Alcides haemopterus* Boh. (Coleoptera : Curculionidae) proved to be a serious pest attacking and destroying flowers. It is widely distributed throughout the area. *Pachnoda marginata* Dury. (Coleoptera : Cetoniidae) was also recorded attacking flowers.

Bananas in the Nuba Mountains were little affected by pests but the following insects were recorded ; *Serinetha amicta* Germ. (Hemiptera Coreidae) attacking ripe fruit, *Apion* spp. (Coleoptera : Curculionidae), *Dacus* spp. (Diptera Trypaneidae), *Diopsis* spp. (Diptera : Diopsidae) which is thought to feed on overipe fruit.

III. Commercial Spraying Experiments in the Gezira and White Nile Schemes.

Single and Double Applications of D.D.T.

Layout

A large scale experiment on X1730A cotton was carried out in Hag Abdalla and Fahl Blocks of the South Group. The following treatments were applied :—

	1.0 lb. DDT/Fed.	0.5 lb. DDT/Fed.
Sprayed 27/29 Sept. (Early)	1	2
Sprayed 14/15 Oct. (Late)	3	4
Sprayed early and late	5	6

It was not possible to secure a sufficiently large area of unsprayed cotton to provide an unsprayed control treatment.

Each of the 6 treatments was applied to half cotton Numbers (90 feddan fields) and the whole replicated 10 times in each Block, but only the central 30 feddans of each half Number were considered in the assessment. In Hag Abdalla the insecticides were applied by aircraft in 3 gals. of spray per feddan and at Fahl in 2 gals. of spray per feddan.

Insect Assessment

A summary of counts of percentage of leaves infested with thrip larvae and number of jassid nymphs is given in table 7.

Analysis of pre-spray thrip infestation on Hag Abdalla Block showed significant block differences, but no treatment differences. An analysis of covariance of sowing date and thrip infestation showed no significant correlation, and the block variability must be due to some undetermined factor. These statistical "blocks" are, in fact, groups of adjacent numbers, and watering regimes may be variable. There was no difference in the total thrips infestation recorded between the date of the first spray and 10th November (when counts ceased) on the single early and single late spray treatments, though a difference in time of attack was observed. The double spray gave complete control of thrips 0.5 lbs D.D.T. Per feddan gave as satisfactory contol as 1.0 lbs., and 2 gals. of spray per feddan was as good as 3 gals.

Records were also made of the incidence of jassid and whitefly on the 6 treatments.

Table 7.

Aerial spraying in Hag Abdalla and Fahl Blocks 1953.

Jassid nymphs per 100 leaves and % of leaves infested with thrips larvae : the pre-spray counts are the mean of 1-4 counts each taken on a 500 leaf sample from each of 5 replicates of each treatment : the post-spray counts are the means of 4-8 counts taken on a similar sample : the counts cover the period 22 September — 10 November.

Vol. rate fed.	Treatment	Jassids per 100 leaves			
		0.5 lbs. DDT/Fed.		1.0 lbs. DDT/Fed.	
		Mean pre-spray	Mean post-spray	Mean pre-spray	Mean post-spray
2 gals.	Sprayed early ...	38.4	7.4	35.0	7.2
	Sprayed late ...	51.0	2.4	44.7	0.5
	Sprayed early and late ...	32.8	4.9	21.8	1.7
3 gals.	Sprayed early ...	31.0	3.0	25.0	4.5
	Sprayed late ...	32.8	1.8	25.7	1.1
	Sprayed early and late ...	30.8	2.2	52.0	2.9
Mean of all counts		36.2	3.6	34.0	3.0

Vol. rate fed.	Treatment	% leaves infested with thrips larvae			
		0.5 lbs. DDT/Fed.		1.0 lbs. DDT Fed.	
		Mean pre-spray	Mean post-spray	Mean pre-spray	Mean post-spray
2 gals.	Sprayed early ...	4.0	6.0	1.2	5.9
	Sprayed late ...	8.2	0.5	7.6	0.0
	Sprayed early and late ...	2.6	0.3	5.2	0.0
2 gals.	Sprayed early ...	6.6	4.9	6.8	4.8
	Sprayed late ...	9.1	0.8	9.8	0.0
	Sprayed early and late ...	4.0	0.4	6.0	0.3
Means of all counts		5.7	2.1	6.1	1.8

At both Hag Abdalla and Fahl there was a significant negative correlation between pre-spray counts of jassids and sowing date ; *i.e.* the later sowing date the lower the initial jassid population. The late sprayed treatments (3 and 4) supported significantly more jassid than the treatments receiving an early spray (1, 2, 5 and 6) between 29 September and 14 October (date of application of late spray). Treatments receiving 0.5 lb DDT per feddan supported more jassids after spraying than those receiving 1.0 lbs. DDT but the difference just failed to reach signficance at the 5 % level. There was a recovery in jassid numbers during November on treatments sprayed early, this being greatest in treatment 2 which received 0.5 lbs. DDT. This recovery did not occur in any treatment receiving a later spray.

Whitefly in Hag Abdalla were reduced in numbers by the first spray, all treated plots showing significantly lower counts than the unsprayed, but only a 50% reduction. After the 2nd spray those plots which had received one early spray (1 and 2) had the greatest population. There was no significant difference in numbers on plots receiving the single late (3 and 4) or double spray 5 and 6. Two weeks after the late spray populations on all treatments had evened out. There was a significant difference between the control achieved by 1.0 lbs and 0.5 lbs. DDT per feddan, the former being superior. Data on whitefly were summarised in table 8.

Table 8.

Aerial Spraying in Hag Abdalla Block 1953.

Incidence of whitefly after 2nd. spray application.

(14/15 October).

(Square root of treatment means of 5 replicates in each of which was recorded the number of w/fly adults in a sample of 250 leaves taken at random from each treatment).

	Treatment	After early spray	After late spray
1.	Sprayed early 1.0 lbs.	30.4	83.5
2.	„ „ 0.5 „	25.9	81.1
3.	„ late 1.0 „	46.2	15.2
4.	„ „ 0.5 „	43.9	36.4
5.	„ early and late 1.0 lbs.	26.0	17.0
6.	„ „ „ „ 0.5 „	30.8	38.1
	Mean	33.9	45.6
	S.E.	2.75	5.86

Similar counts were obtained in Fahl.

Yields

The yields obtained in this experiment are shown in table 9.

Table 9.

Hag Abdalla and Fahl Blocks 1953.

Yields k.p.f.

	Hag Abdalla		Fahl	
	1.0 lbs.	0.5 lbs.	1.0 lbs.	0.5 lbs.
Early spray	5.00	5.18	5.07	5.00
Late spray	5.59	5.32	4.30*	4.50*
Early and late spray	5.13	5.52	4.97	4.96
Mean	5.24	5.34	4.78	4.82
Block means	5.28		4.80	
S.E. (treat. mean)	0.17		0.17	

*Significant difference at P = 0.05.

In Hag Abdalla none of the treatments resulted in yield differences. In Fahl the treatments receiving a late spray yielded significantly less than the other sprayed treatments.

Grade.

Analysis of the original figures of yield of grades 1-5 showed no differences in Fahl, but on Hag Abdalla the late spray with 1.0 lb. DDT and both double spray treatments (3, 5 and 6) yielded more of these grades than the other treatments (1, 2 and 4).

There was, however, a large variation in sowing date and a negative correlation between sowing date and grade; on Fahl r=0.616 and on Hag Abdalla r=0 699. The regression for sowing date and yield of grades 1-5 was calculated for both localities and the actual yields corrected to the mean sowing date. Analysis of the corrected yield then showed that there were still no difference in Fahl. On Hag Abdalla the single early spray treatments (1 and 2) gave the lowest yield of good grade (viz. grades 1-5). Grade was generally low in this experiment.

In the absence of unsprayed controls few conclusions can be drawn from these experiments. The general outcome can be summarised as follows:—

(i) 1.0 lb. DDT v. 0.5 lb. DDT per feddan: both dosage rates achieved an equal control of thrips and jassids. 0.5 lbs. DDT gave an inferior kill of whitefly adults.

(ii) Two spray applications gave complete control of thrips and almost complete control of jassids. After recovery from initial knockdown, numbers of whitefly adults on the twice sprayed treatments were as numerous in November as on those treatments receiving a singles pray. All single spray treatments resulted finally in a low but similar infestation of thrips and jassids but there was a difference in the time of attack between early and late spray application.

(iii) In Fahl the late spray treatments resulted in the lowest yield and were associated with a significantly greater early attack of jassids, whitefly and thrips.

(iv) In Hag Abdalla early spray treatments resulted in lowest yield of grade 1-5, associated with a later attack of jassids, whitefly and thrips.

Repeated Application of DDT Spray

Layout

A large-scale experiment was carried out in Remeitab Block of the South Group where the following treatments were applied to BAR XL1 cotton, sown between 2 and 17 August :—

1. Unsprayed.
2. Sprayed once with DDT.
3. Sprayed 3 times at 2 weeks intervals.
4. Sprayed 4 times at 10 day intervals.
5. Sprayed 6 times at 7 day intervals.

Each treatment was applied to the central 30 feddans of each half of a standard 90 feddan cotton Number and the 5 treatments replicated 5 times. Spray application was by aircraft applying 1.0 lbs. DDT in 3 gals. of spray per feddan.

Jassids, Thrips, Aphids

One spray was sufficient to reduce the population of jassids and thrips to extremely low levels, although in each case there was evidence of a small recovery towards the middle of November. These counts are shown in table 10.

Table 10.

Repeated Spraying of DDT.

Remeitab Block.

Jassids, Thrips and Aphid infestation.

Totals counted on 9 occasions between 13/9 and 17/11
500 leaves being sampled on each occasion.

Treatment	Jassid (Nymphs)	Thrips (infected leaves)	Aphids (4 occasions 2/10-17/11)
Unsprayed	2,201	424	35
1 spray	70	59	23
3 sprays	9	1.2	202
4 sprays	10	0.0	238
6 sprays	13	3.6	265

The aphids showed an increase with increased numbers of sprays : all populations were, however, very low.

There was no correlation between any of these counts, and the yields, or grades of cotton.

Whitefly

There were counted also on 9 occasions, and the totals for each treatment (250 leaves per sample) are listed below :—

Table 11

Repeated Spraying of DDT.

Remeitab Block.

Whitefly infestations.

Totals counted on 9 occasions between 13 9 and 17/11

250 leaves being sampled on each occasion.

Treatment	Total whitefly (adults)
1. No spray	9,243
2. One spray	14,182
3. Three sprays	7,843
4. Four sprays	8,125
5. Six sprays	3,357

Treatment mean counts were analysed for the nine sampling dates after using a square-root transformation. This showed that :—

(i) the six sprays had a lower population than all other treatments at 0.1% level of probability.

(ii) One spray gave a higher population than 3 or 4 sprays at 5% level probability—the increase being of the order of 53%.

(iii) three and four sprays showed no difference in population from the control.

Yields.

Yields are summarised in table 12.

Table 12.

Repeated Spraying of DDT.

Remeitab Block.

Total yields and yields of grades 3-5 (k.p.f.)

Treatments	Total yield k.p.f.	Yield of grades 3-5 k.p.f.
1. Unsprayed	3.8	1.4
2. One spray	4.3	0.9
3. Three sprays	4.4	1.3
4. Four sprays	4.0	1.5
5. Six sprays	4.8	2.3
Mean	4.27	1.46
S.E. (Treat. Mean)	0.29	0.17

Analysis of variance on total yield showed differences were not significant. Yield of grade 3-5 showed, however, highly significant differences; treatment 5 (6 sprays) being greater than all other, and treatment 2 (1 spray) being less than treatment 1, 3 and 4 which were not different.

The difference in whitefly population showed no correlation with total yield of cotton.

Grade

The bulk of the crop fell within grades 4-9. Table 13 shows the crop from each treatment divided into two groups, viz. grade 4 + 5 and grades 6 + 9, also listed are the treatment means for whitefly adult counts. The very close relationship between whitefly and grade is seen even more clearly when percentage of crop in grade 6 + 9 is plotted against mean whitefly count, for each treatment. Analysis of these results after an angular transformation of percentage to degrees, showed a highly significant positive correlation between the whitefly counts and percentage of crop in the lower grades, (6 + 9). The correlation coefficient was 0.96, *i.e.* 92% of the increase in low grade was related to increase in whitefly numbers.

Table 13.

Repeated Spraying of DDT.

Remeitab Block.

Whitefly and Grade Correlation.

Treatment	Mean adult Bemisia per 250 leaves	% in Grade 4 + 5	% in Grade 6 + 9
1	1,773	20.82	78.97
2	1,115	29.99	70.01
3	980	29.98	69.67
4	1,016	35.47	64.34
5	419	42.94	56.04

The grade from the experiment as a whole was very low—no cotton falling in grade 1 and 2, and extremely little falling in grade 3. If the relationship between whitefly and grades is constant at the lowest level of whitefly attack, by extrapolation it appears that in the absence of whitefly, about 50% of the crop would have fallen in grade 6 and 9.

One cannot entirely separate the effects of jassid and whitefly on the crop. But treatment 3 (3 sprays) with jassids eliminated, and the same whitefly population as the controls, has the same poor grades as the control themselves. It was not until the whitefly numbers were reduced, that grade improved. It appears therefore that in this area whitefly were of greater importance than jassids, and DDT spraying increased their importance. It is problematical what the correlation of whitefly with poor grade means. The bollworm data were inadequate for making an adequate statistical analysis between treatments, but summaries of treatment means are given below:—

Table 14.

Repeated Spraying of DDT.

Remeitab Block.

Bollworm damage

Treatment	% of fruiting points shed.		% Bollworm attack on shed buds and bolls	
	December	January	December	January
1. No spray	48.7	53.9	81.2	62.3
2. One spray	52.0	50.6	71.2	62.4
3. Three sprays ...	50.8	53.6	81.7	64.7
4. Four sprays	51.8	52.0	67.8	58.7
5. Six sprays	52.3	54.6	66.7	54.0
Mean	51.1	52.9	73.7	60.4

All that can be concluded from these figures is that there were no differences in the proportion of fruiting points shed (estimated in December and January); but that there was tendency for more sprays to reduce the percentage of fruits shed in association with bollworm attack. An examination of the relationship between damage to shed materials, and low grade, showed also a significant positive correlation $r = .80$ for the bollworm counts in January, but not for the counts in December.

It must be concluded, therefore, that the improved grade resulting from increased numbers of DDT sprays resulted from control of earlier whitefly, and later bollworm damage.

An analysis was then made of differences between treatments of total nodes, total shedding and total buds, from counts made in December. These are summarised in table 15. All figures are expressed as numbers per 20 plants and the bud counts were transformed to logarithmic values for analysis.

Table 15.

Repeated Spraying of DDT.

Remeitab Block.

Numbers of fruiting nodes produced, fruiting points and buds present per 20 plants in December 1953.

Treatment	Total nodes (Arithmetic means)	Total sheds (Arithmetic means)	Total buds (Geometric means)	
			Log. (n+1)	
1. No spray ...	593	289	1.91	79.6
2. One spray ...	657	315	2.16	145.9
3. Three sprays...	604	307	1.96	91.2
4. Four sprays ...	585	282	1.70	50.1
5. Six sprays ...	527	252	1.16	14.5
Mean	575	289	1.78	60.25
S.E.	136	22	.02	

There was no apparent difference in total nodes, or total shed fruiting points at this stage. There were, however, significantly more buds present on treatment 2, and fewer on treatment 5 than on treatment 1, 3 or 4. These differences in buds present in December were significantly correlated with (a) whitefly attack (b) low grade, but there was no correlation with the % bollworm attack on shed material, for either the December or January counts.

The crops in which whitefly and bollworm were reduced (treatment 5, 6 sprays) produced an earlier crop of better grade. Conversely, where whitefly were increased (treatment 2) or bollworm was not controlled (treatment 1 and 3) a later crop was produced, of poor grade. Treatment 1 and 3 still produced better grade than treatment 2. The counts of buds in December provided a good indication of the differences in development viz. those plants which were still growing had the highest bud counts, while those which had set most of their crop by then and had virtually ceased growth showed the lowest counts.

This reasoning leads to the conclusion that the effects of both whitefly and bollworm were to produce late poorer grade cotton. It is to be noted that although the graders endeavour to group into 7 grades. in this analysis the yields which fell into only 5 grades, were grouped into " high-grade " groups 3, 4 and 5 and " low grade " group 6 and 9.

Conclusions

1. The data from this experiment show quite clearly that in Remeitab a single spray of DDT against jassid increased whitefly and reduced grade. Reduction of whitefly and bollworm by repeated application of DDT improved grade.
2. The level of whitefly in Remeitab on the unsprayed controls, in itself may have reduced grade.
3. None of the insects observed could be shown to have had any effect on total yield.

Layout (1)

An experiment was laid out in Tebub Block of the Messelemiya Group where the following treatments were applied to Domain Sakel cotton.

1. Not sprayed with parathion.
2. Sprayed once with parathion at a rate of 0.25 lbs. active ingredient in 50 gals. of spray per feddan.
3. Sprayed twice with parathion on each occasion at the rate described for treatment 2.

Each treatment was applied to a single 10 feddan plot and the whole was replicated 9 times. An indentical layout was adopted in Saadalla Block of Messellemiya Group where the same treatments were applied to early-sown BAR XLI cotton.

All the cotton in both Blocks received, before the experimenta treatments, the routine spray of 1.0 lbs. DDT per feddan, on this occasion applied by aircraft in 2 gals. of spray per feddan.

Yield

Total yields and yields of grades 1-4 are summarised in table 16.1 In Saadalla Block analysis of yields of grades 1-4 required logarithmic transformation and analysis of the percentage yield of these grades by angular transformation of the data.

Table 16.

Control of whitefly by parathion sprays.

Tebub and Saadalla Blocks.

(i) Tebub.

Treatment	Mean total yield.	Mean yield Grades 1-4	Mean % yield Grades 1-4
1. One parathion	5.12	0.67	13.2
2. 2 parathion	5.67	0.55	9.9
3. No parathion	5.17	1.16	22.9
Mean	5.32	0.79	15.4
S.E. (Treat. mean)	0.10	0.07	1.52

(ii) Saadalla

Treatment	Mean total yield	Mean yield Grades 1-4		Mean % Grades 1-4	
		Original data	log (n+1)	Original date	Degrees
1. One parathion	4.52	0.41	0.15	8.9	17.1
2. 2 parathion...	4.58	0.27	0.10	5.9	13.5
3. No parathion	4.39	0.49	0.17	11.5	19.5
Mean	4.50		0.14		16.7
S.E. (Treat.mean)	0.21		0.115		1.2

	Tebub	Saadalla
(a)	Total yield - Treatment 2>1 & 3 at .1%	No difference.
(b)	Yield Gds. 1-4 ,, 3>1 & 2 at .1%	Treatment 2<1 & 3 at 1%.
(c)	% yield Gds. 1-4 ,, 3>1 & 2 at .1%	Treatment 2<1 & 3 at 1%.

Only in Tebub, was an increase in total yield obtained by applying 2 parathion sprays. In both cases, however, this treatment reduced the total yield of higher grade cotton; in Tebub, the single parathion spray also reduced yield of higher grade.

An examination of the insect counts provides the reason for this unexpected result.

Insect infestation

Summaries of jassid and whitefly counts, and percentage bollworm damage to shed material, are given in table 17.

Table 17.

Saadalla and Tebub.

Control of whitefly by parathion sprays.

Post-spray counts

Record	Tebub				Saadalla			
	Date	T.1	T.2	T.3	Date	T.1	T.2	T.3
Jassid/100 plants, Geometric means ...	7/11	81	4	231	11/11	68	5	155
Whitefly per 100 leaves, Geometric means ...	7/11	141	16	277	15/11	27	1	52
% BW attack on shed material ... ... means of 13 counts ...	11/11 to 12/12	78	81	66	14/11 to 26/12	84	88	81
% Crop, Poor grade ...		87	90	77		91	99	89
Yield Gd. 1-4 k/f ...		0.67	0.55	1.16		0.41	0.27	0.49

The jassid and whitefly counts were the second record taken after the application of both parathion treatments, and illustrate the greater reduction in number of both insects obtained by the double application of parathion.

Detailed analysis of whitefly counts have been done for Tebub only and can be summed up :—

(a) After the first parathion spray (6-10 10) to treatments 1 and 2, arithmetic mean counts per 100 leaves on 18-26 10 were. 90, 156, 442 respectively for treatments 1, 2 or 3, treatment 1 and 2 significantly less than treatment 3.

(b) After treatment 2 had received its second parathion (20-25/10) counts on 7/11 were 172, 29, 217 : all three treatments were significantly different but the effect of one spray was clearly diminishing.

(c) On 18/11 counts were 754, 202, 917. Treatment 1 was no longer controlling whitefly, while treatment 2 still showed a significantly lower count.

(d) After this count the whole population diminished and there was no residual effect of any treatment, on very low population.

From these observations, it appears that a single spray of parathion, remained effective against whitefly for 24-28 days after application : the effect against jassid appeared to be the same.

The marked effect of the parathion treatment in reducing both jassid and whitefly, was not reflected in increased total yield at Saadalla, but there was a small significant increase in Tebub on treatment 2. Considering the relationship with grade in these instances, there was a positive tendency for better grade to be associated with increased numbers of both jassid and whitefly. The bollworm records, *i.e.* counts of bollworm (predominantly *Heliothis*) attack of shed buds and bolls, showed an inverse relationship, and parathion appeared to have increased this damage. All this is apparent from an examination of table 17. An analysis was then made of the relationship between attack, and poor grade. For both Tebub and Saadalla, the correlation coefficient were .99 which is significant at 5%.

In Tebub, all plots received a dressing of sulphate of ammonia. and there were no differences in sowing date between treatments. The positive correlation between bollworm attack and poor grade is probably a real one. The effect on total yield of increased bollworm attack was outweighed in Tebub by the benefit gained from control of jassid and whitefly. On Saadalla however, the increase in bollworm cancelled any benefit resulting from the control of jassid and whitefly.

In contrast with Remeitab, the correlation between whitefly and poor grade was negative. In both Blocks, the effect of bollworm in reducing grade appeared to have outweighed the benefit resulting from control of whitefly. Bollworm could reduce grade in the same way as whitefly appeared to do in Remeitab *i.e.* by delaying cropping.

The bollworm records used in these analysis were those taken from mid-November to the middle or end of December, when the attack was generally heavy, but greater on Saadalla.

Layout (2)

An experiment was carried out at Um Gerr Pump Scheme of the White Nile Schemes Board, when the following treatments were applied to BAR X1730A LI cotton :—

1. Sprayed with DDT only.
2. Sprayed with DDT and parathion.
3. Sprayed with DDT and parathion, followed by a parathion spray 15 days later.

The DDT sprays were applied at a rate of 1 lb. technical DDT in 16 gals. spray per feddan. The DDT-parathion mixture of 1 lb. DDT and 0.25 lbs. parathion was sprayed in 50 gals. per feddan. The parathion spray (treatment 3) contained 0.25 lbs. parathion in 50 gals. spray per feddan. Each treatment was applied to a 5 feddan plot and a randomised block design adopted in which the 3 treatments were replicated 10 times.

Insect assessment

All treatments reduced jassid numbers to insignificance. Sprays which include parathion reduced adult whitefly to insignificance for 2 weeks after spraying. There was a smaller reduction of nymphal infestations for at least one month after spraying.

The parathion treatments had little effect on the number of fruiting points shed, which until December when observations ceased, never exceeded 13% of the total fruit production. Nevertheless a greater number of fruiting points, chiefly buds, were shed in November in association with *Heliothis* damage in parathion than in DDT sprayed treatments. No such differences were found in December.

Yields

The following yield results are obtained :—

1.	DDT only	4.02 k.p.f.
2.	DDT + parathion	4.61 ,,
3.	DDT + parathion + parathion	4.84 ,,
	S.E. (treatment mean) ..	± 0.209 ,,
	Least sig. diff. (P=0.05) ..	0.621 ,,

Treatments sprayed with parathion yield better than those sprayed with DDT only. In the case of the single parathion spray this increase just failed to reach significance at 5% level. In the case of the 2 parathion sprays the increase just failed to reach significance at the 1% level.

Insect Control by DDT in 2 and 3 Gals. of Spray per Feddan

This comparison was carried out on Domains Sakel cotton at Abu Gin in the North Group and X7130A cotton at Keteir in the West Group. The following treatments were applied at random throughout the 2 Blocks, each to complete 90 feddan Numbers.

1. Sprayed by aircraft applying 1.0 lbs. DDT per feddan in 3 gals. of spray per feddan.
2. Sprayed by aircraft applying 1.0 lbs. DDT fer feddan in 2 gals. of spray per feddan.

No insect counts were made in this experiment, but yields were subsequently analysed from 26 Numbers of comparable areas of cotton. The results are summarised in table 18.

Table 18.

Reduction in volume application of spray by aircraft

Yields in k.p.f.

Block.	Variety	2 gals. spray per feddan	3 gals. spray per feddan	Mean
Keteir	X1730A	5.54	5.54	5.54
Abu Gin	D. Sakel	4.08	4.28	4.14

Spraying dates:— Abu Gin 25-29/ 9 mean 27/9
Keteir 9-16/10 mean 13/10

It is concluded that no differences resulting from the 2 treatments are reflected in the yield of either variety.

Further Reduction in Volume Rate of Spray Application by Aircraft

Layout

A large scale experiment was carried out in Hosh Block and Wad Naaman Block of the South Group to investigate the effects on yields and grade, and control of jassids, whitefly and thrips of the following treatments, when applied to X1730A cotton.

	60 ft. Swath	90 ft. Swath
0.0 gals/fed.	1	2
0.4 ,, ...	3	4
1.0 ,, ...	5	6
2.0 ,, ...	7	8

All treatments were applied by aircraft spraying 1.0 lbs. DDT per feddan. A split plot design was adopted, each main treatment being on 60 feddans of a 90 feddan field, the whole being replicated 5 times.

Yields

Yield results are given in table 19.

Table 19.

Reduction in volume rate of spray application.

Hosh, Wad Naaman Blocks.

Yields in k.p.f.

	60 ft. swath.	90 ft. swath.	Mean of main treaments
Unsprayed	4.68	5.20	4.94
0.4 gals/fed	4.08	4.67	4.37
1.0 gals/fed	5.34	4.74	5.04
2.0 gals/fed	4.38	4.69	4.53
Mean	4.62	4.82	4.72

S.E. (treatment mean) main treatment 0.23 k.p.f.
S.E. (treatment mean) swath widths 0.12 k.p.f.

The yields showed no benefit from spraying. There was no difference resulting from spraying different swath widths.

Grade

Analysis was done for Average Grade, as detailed grading was not available. A first examination of the grade figures showed that differences were not worth analysing, and were insignificant.

In view of the wide range of sowing dates in this experiment a range of 14 days from 14-28 August, over the 20 Numbers utilised in the experiment, an analysis of sowing date : grade was done. This showed a significant correlation between the two factors : viz. the later the sowing, the higher the index for Average Grade and the lower the quality of the crop. The regression was calculated, and all grade values " corrected " to the mean sowing date. An analysis of these corrected figures showed no significant differences between treatments.

Table 20.

Hosh and Wad Naaman Blocks 1953/54.

Average Grade — Correct to mean sowing date.

Gallons per fed. ...	0	0.4	1.0	1.0	Mean	S.E.
Mean Av. grade ...	5.35	5.46	5.47	5.46	5.44	0.18
%	98.3	100.4	100.6	100.4	100.0	3.3

The Average Grade of sprayed plots was 5.46, compared with 5.35 on the controls.

Jassids

For purpose of analysis the counts of jassids from sub-plots were summed, since there was no difference between 60 ft. and 90 ft. swaths.

Detailed analysis of counts taken at 19-20 days and 32-34 days respectively after spraying are given in table 21.

Table 21.

Reduction in volume rate of spraying application.
Hosh and Wad Naaman Blocks.
Jassid infestation : log (N+ 1).

Treatment.	Jassid per 1000 leaves Days after spray		Percentage of mean Days after spray	
	19-20	32-34	19-20	32-34
Unsprayed	2.59	2.50	190.4	174.8
0.4 gals/fed.	1.25	1.56	91.9	109.1
1.0 „	0.89	1.27	65.4	88.8
2.0 „	0.73	0.40	53.7	28.0
Mean	1.36	1.43	100.0	100.0
S.E. (Treat.mean)	0.15	0.33	11.0	22.8

On both occasions all treatments showed significantly lower jassid counts than the controls. In addition, the 2.0 gallons showed better control than the 0.4 gallons, which was showing a recovery in population by early November.

Whitefly

The first noticeable feature was the fall in numbers on the control plots at the time when spray treatments were applied. There were no treatment differences in the count made before and immediately after spraying. Analysis of the two later post-spray counts (19-20 and 32-34 days after spraying) are summarised in table 22.

Table 22.

Reduction in volume rate of spray application.
Hosh and Wad Naaman Blocks.
Whitefly infestation : Square root.

Treatment	Whitefly per 1000 leaves Days after spray		Percentage Days after spray	
	19-20	32-34	19-20	32-34
Unsprayed	60.5	47–5	84	76
0.4 gals/fed.	74.9	62.8	104	101
1.0 „ „	79.5	72.6	110	117
2.0 „ „	72.0	65.1	100	105
Mean	71.7	62.0	100	100
S.E. (Treat.mean)	5.7	7.7	8	12

On both occasions the sprayed plots showed a significant increase in whitefly. There was no difference between spray treatments, indicating that reducing the volume of spray in no way prevented the increase of whitefly following one spray application.

Whitefly : Grade Correlation

Average Grade corrected to mean sowing date, and whitefly recorded 19-20 days after spray were subjected to an analysis of covariance. The residual showed an insignificant correlation, but there was a significant correlation (5%) for blocks, between the two factors, *i e.* the block variation in whitefly counts noted on this occasion were significantly correlated with later block differences in average grade.

Conclusions

(i) Spraying at 0.4, 1.0 and 2.0 gal/feddan gave the same yield and grade, whether applied on 60 ft. or 90 ft. swath.

(ii) Jassid counts. All treatments significantly reduced populations, 2.0 gals. being consistently best.

(iii) Whitefly counts. An initial post-spray fall in numbers occurred on all plots, including the controls. Thereafter the sprayed plots showed significant increases in population compared with the unsprayed plots. It appears that the very low volume spray 0.4 gal/feddan, is no better than the other sprays in respect of the build up of whitefly following one application.

(iv) None of the spray treatments improved yield or grade.

Reduction in Volume Rate of Spray Application by Land Machine

Layout

A large scale experiment was laid out in Abdel Hakim Block of the Central Group in the Sudan Gezira where the following treatments were applied to X1730A cotton.

1.0 lbs. DDT in 10 gals. spray per feddan.
1.0 ,, ,, ,, 5 ,, ,, ,, ,,
1.0 ,, ,, ,, 2.5 ,, ,, ,, ,,

Each treatment was applied by tractor mounted equipment to a single 10 feddan field and the whole replicated 12 times. Owing to lack of supervision in several cases 2 treatments were bulked and 5 replicated results were thus lost. Of the remaining 7 replicates only 4 were used for insect assessment.

Yields

Total yields and yield of grades 1-5 are given in table 23.

Table 23.
Reduction in volume rate by land machine.
Abdel Hakim Block.
Yields in k.p.f.

Treatments	Total yield	Yield of Grades 1–5
10 gals/fed.	5.6	1.0
5 ,, ...	5.2	0.9
2.5 ,, ...	5.5	0.9
Mean	5.4	0.9
S. E. (treat. mean)	0.26	0.21

There were no treatment differences in total yield. or of grade 1-5. On the total yield there were highly significant replicate differences. On this occasion a 90 feddan field represented a statistical block, each treatment being on 3 adjacent 10 feddan fields and inter-plot effects might have influenced the results.

Insect counts

Since insect counts were made on only 4 replicates, and there were no trends in yield or grade, no covariance analysis were made for any of the insect counts. The control of thrips was equally effective on all 3 treatments Jassids were killed more slowly with 2½ gal fed. than 10 gals fed. but eventually an equally effective control was obtained. This was apparent in the first count after spraying, pre-spraying counts being not significantly different. This is shown in table 24.

Table 24.

Reduction in volume rate by land machine.

Abdel Hakim Block.

Jassid infestation one week after spraying.

Treatment	Jassid per 500 leaves (Square root + 1/2)
10 gals/fed.	1.4
5 „	2.1
2.5 „	7.4
Mean	3.4
S.E. (treatment mean)	0.7

There were no differences in whitefly counts at any stage before or after spraying.

From these results it appears that although 2.5 gals. of spray pe feddan gave a slower kill of jassids it eventually gave as a good a contro as 10 or 5 gals. per feddan and yield and grade were unaffected.

Reduction in Dosage Rate of DDT

Layout

In Medina Block in the Central Group, 17 cotton Numbers were divided into two, one half being sprayed with DDT at 0 75 lbs. and the other half at 1.0 lbs. per feddan. The rest of the Block was sprayed with 0.75 lbs. DDT per feddan.

Yields

Analysis of yield from these split numbers gave the result summarised in table 25.

Table 25.

Reduction in dosage rate of DDT.

Medina Block

Treatment	1 lb.	3/4 lb.	Mean	SE Treat.mean
Yield k.p.f.	5.02	5.48	5.25	0.12

The treatment difference was significant. There were no insect counts to compare with these yield differences.

IV. Research in The Gezira.

The Biology, Status and Control of the Cotton Fleabeetle

Taxonomy

D. G. Pollard, studying the taxonomy of *Podagrica* concludes that *P. puncticollis* in the Sudan consists of a mixture of two species, one the true *P. puncticollis* related to *P. uniforma* of West Africa, the other probably *P. pallida*. It is not yet possible to say how far this information will necessitate revision of the ecology and behaviour; there is a possibility however that in outbreak years the two species are in equal proportion, in "light" years *P. puncticollis* predominates.

The result of this investigation has been submitted for publication.

Ecology

The emergence from aestivation, distribution of fleabeetle on fallows and on cotton were studied by M. R. Norman and R. Simons.

Emergence from aestivation

This aspect was studied with the aid of traps designed for collecting adults emerging from the soil. The traps were placed in Saadalla Block either on fallow following cotton (cotton 1952/53) or on fallow to be cropped with cotton in 1953/54. Five 90 feddan fields were selected for each of the two phases of the rotation, each field having 50 traps. The traps were in position from June to August, and were examined 7 times in June, in mid-July and 9 times in August. Very few fleabeetle were caught; the total recovered from fallow following cotton was 30, while 11 were recovered from fallow to be cropped with cotton during the current season. This result confirmed previous conclusions based on soil washing that the fallow which follows cotton is a source of infestation of flea-beetle.

Incidence of fleabeetle on fallows

A fallow survey was carried out in four Blocks of the Central Gezira (A Galil, Saadalla, Tebub and Sileimi) in August. In its course 94 entire 10 feddan fields were examined. In each the total number of self-sown cotton, bamia, weika, *Hibiscus esculentus* and *Abutilon*, as well as the number of flea-beetle present on each of these hosts, were recorded.

Three types of fallow were included in the survey, viz: that after cotton in 1951/52, that after cotton in the preceding year, 1952/53, and that after dura in 1951/52. A summary of results is given in table 26. The figure of most interest is the average number of 14.6 flea-beetle recorded per 10 feddan field. In the survey of cotton the average number of fleabeetle recorded immediately afterwards on cotton from 320 plant-hole-samples was 62.2 which is equivalent to 21,380 adults per 10 feddan field. The big difference between the

fallow average and the estimated cotton average, as well as the small numbers of hosts recorded in the fallows, make inescapable the conclusion that weeds in the fallows, and the infestation upon them cannot, through their scarcity, play an important part in the development of fleabeetle infestation on cotton.

Table 26.

Incidence of fleabeetle hosts and adults in fallows.

	Cotton	Bamia	Weika	Abutilon spp.	All hosts
Average number of hosts per 10 feddan field	0.5	2.0	1.9	3.0	7.0
Average number of fleabeetle per host	2.1	1.9	1.9	2.4	2.1
Average number of fleabeetle field	1.1	3.9	3.5	6.2	14.6

NOTE: Averages based on 94 observations.

Abutilon seemed more attractive than self-sown cotton, whereas the latter was superior in this respect to bamia and weika, there being no difference between the last two. Table 27 shows differences that existed between the three types of fallows in respect of host and adult numbers. The lowest number of hosts per howasha was recorded on land where the latter was preceded by cotton in the previous year, a result not surprising in view of the importance attached to weed removal in the Gezira cotton crop. On the same land, on the other hand. the average number of fleabeetle was highest. This is probably explained by the fact that a fallow after cotton, is likely to be a more important source of aestivating adults than other fallows.

Table 27.

The incidence of fleabeetle hosts and adults in three different types of fallow.

	Fallow after		
	51/52 cotton (17)	52/53 cotton (53)	51/52 dura (24)
Average number of hosts per 10 feddan field	18.7	2.6	8.6
Average number of fleabeetle per host	2.04	2.58	1.8

N.B.—Figures in brackets denotes numbers of observations on which the averages were based.

All hosts, even if found singly in the middle of a fallow, were without exception infested, and it is inferred that the fleabeetle is a very active flyer and widespread at the time of cotton sowing.

The incidence of infestation in a young cotton crop

Extensive fleabeetle counts were carried out in a large number of fields scattered over 3 Gezira Blocks: Tebub, Abdel Galil and Seleimi. A total of 196 examinations were made.

The survey consisted of flea beetle counts in selected cotton Numbers, the two end fields (usually A and I) and one middle field (either D or E) being examined in each Number. The total sample from each howasha was 320 plant-holes, 20 plant-holes being examined in each angaia. Plant-holes for examination were selected from rows: 1, 4, 7, 10, 13; 57, 60, 63, 66, 69; 113, 116, 119, 122, 125; 167, 172, 175, 178, 181; thus giving a sampling pattern of four parallel and equidistant lines running across angaias.

Results

The results of the survey have confirmed the view that the intensity with which different areas of the young cotton crop are attacked by fleabeetle varies. The variation may occur between 10 feddan fields and between blocks of 9 ten feddan fields (Number) and it has its basis in the lateness or earliness of the crop. By arranging the results from examined fields in order of sowing dates it was possible to show that cotton sown between the 12th and the 18th August was more heavily infested than cotton sown from the 19th August onwards.

In table 28 are given 5 day averages of numbers of fleabeetle recorded in three Gezira Blocks on early and late-sown cotton. It can be seen that the average numbers of fleabeetle per 10 feddan. fields were higher on fields that were sown within a week of the start of sowing (12th August). The difference on the Seleimi Block were less conspicuous, if not altogether absent, but this was probably due to infestation being too low to show them and a critical counting date being missed.

Table 28.

Flea-beetle infestation at various dates after sowing.

(Numbers recorded on 320 plant-holes per hosha)

No. days after sowing.	Tebub		Galil		Seleimi	
	Early	Late	Early	Late	Early	Late
1-5	58	1	N.A.	N.A.		
6-10	80	4	205	40	42	3
11-15	59	7	232	57	9	7
16-20	45	4	149	24	N.A.	67
21-25	61	3	116	20	36	8
26-32	32	3	62	9	12	11
TOTAL	335	22	764	150	99	96

N.A.—No count made.

The pattern of flea-beetle distribution with 90 feddan fields

In the fleabeetle Research Report. (1952/53) evidence was produced to show that in 14 examined fields an average of 50% of fleabeetle was concentrated in the first four angais adjacent to the Abu XX's (irrigation channel), appr. 22% in the next four, appr. 14% in the next and appr. 14% in the last four angaias adjacent to the non canalised (tagnet) side of the field.

Records are available this season from 103 fields of early cotton, sown between the 12th and 18th August. They confirm the results of the previous season, *i.e.* that there develop infestation gradients across fields, the slopes running from the Abu XX side of Numbers down towards the tagnets, sometimes with a slight rise in the last angaias. The summary of results is given in table 29.

Table 29.

The percentage distribution of fleabeetle across fields

	Percentage distribution of total fleabeetle into angaias.															
Block ...	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Tebub /...	15	9	8	7	7	6	5	6	6	7	5	4	3	4	4	4
Seleimi/...	11	11	8	13	7	6	6	10	5	3	6	3	2	2	3	4
Galil ...	15	11	9	8	7	5	6	4	4	5	3	4	4	4	5	6
Mean of 3 blocks ...	14	10	8	9	7	6	6	7	5	5	5	4	3	3	4	5

The edge effect was present in all of the 133 howashas examined. It was one-sided, with heaviest infestations on the Abu XX sides. Fields selected for survey were orientated geographically in a variety of directions so that geographical orientation did not affect the distribution of the flea-beetle in cotton fields. The Abu XX's on the other hand, proved themselves to be the governing factor.

Sowing in the Gezira starts along the Abu XX's, four angaias being sown in a day. In this way, sowing of a field is completed at the end of the fourth day. Sometimes the operation lasts longer if the weather is unfavourable. The seed germinates in 3 to 4 days time. Since flea-beetle can be found on cotton on the 5th day after sowing it follows that, by the time seedlings come through on the last four angaias, the first four angaias will have been exposed to fleabeetle attack for three to four days, the next four for two to three days, and the next four for one to two days. Moreover, whereas the first four angaias will be attacked on their first day from two sides, when the seedlings on the next four angaias come through, they will be attacked on their first day from one side only which attack will cease the moment seed on the third lot of four angaias germinates. That lot will also be exposed to the attack for one day only until seedlings on the last four angaias come through. During all that time the first four angaias are open to attack all the time.

It is also possible that the phenomenon of preference exhibited by the flea-beetle for older seedlings under experimental conditions, demonstrated by Amsden and Norman, and separately by Pollard (Annual Report 1952 53) also operates in the field by causing a gradual drift of the flea-beetle from the later into the earlier-sown portions of fields. Taking all the facts into consideration it is not unreasonable. to expect that an infestation gradient can build itself up within nine to ten days after sowing. This hypothesis will be tested by experiments in which sowing would be done in the reverse order, *i.e.* starting at the tagnets and finishing at the Abu XXs.

Control

Experiments were carried out in the Gezira in which the protection afforded to cotton by spraying with DDT applied at a rate of 1.0 lb per feddan to the edge 2 angaias (35 m.) by means of a boom supplied with spray by a tractor mounted pump, but carried through the crop by labourers, was compared with that achieved when DDT spray was drifted on to the cotton after being atomised by the exhaust gases as a land-Rover. These gave no results because infestations through out the area were low, and moreover that on the unsprayed control declined similarly to that on the sprayed treatments.

An experiment was carried out on the G.R.F. when early sown cotton was protected against flea-beetle attack by a DDT spray applying 1.0 lb. active ingredient per feddan followed by dusting with B.H.C. Flea-beetle attack was heavy and the treatments gave complete protection to seedlings. In the unsprayed plots seedlings were destroyed by flea-beetle and re-sowing was unusually heavy.

These very striking differences in early growth of the crop were not reflected in final yields, which is summarised in table 30.

Table 30.

The effect of heavy early flea-beetle attack on yields — G.R F. 1953 54.

Yields in k.p.f.

Unprotected	Protected
3.85	3.64
S.E. (treat- mean) ... ... 0.16 k.p f.	
Coef variation. 13.1%	

The Effect of Commercial DDT Spray

Laboratory work has shown, and field observations confirmed, that DDT applied by commercial practice is toxic to whitefly adults. Eggs and other immature stages are also killed when spray particles hit them. Work in previous years (1952/53 Annual Report) has shown that only a small percentage of the spray applied by aircraft with present spray equipment and recovered in the crop reaches the lower surfaces of the leaves. The results obtained from the Remeitab experiment (repeated applications of DDT: see p. 116) have been re-examined to discover the effect of aerial application of DDT to whitefly populations.

The development of the infestation on cotton in the absence of spraying may be obtained from a study of the whitefly counts recorded on unsprayed cotton within the experiment.

The time required in the Gezira for a newly laid egg of *B. gossypiperda* to complete its development and give rise to an adult ready to oviposit is 20-23 days. In the unsprayed treatments a decline in numbers of adults occurred between 1 and 10 October followed by an increase to a peak on 16 October. The number of nymphs almost trebled between 23 September and 30 September and remained nearly constant but increasing in age during the first 10 days in October. Between 10 and 23 October there was a small decline in pupae and an increase in number of young scales, (table 31).

Table 31.

The effect on whitefly numbers of repeated spraying with DDT — Remeitab Block 1953.

Development of whitefly populations on unsprayed cotton immature stages per 100 leaves (estimated from 3 standard microscope fields per leaf).

Date	Immature stages		
	Nymphs	Pupae	Total
21-25 September	433	—	433
1 October	1,085	113	1,198
10 October	482	561	1,043
23 October	501	447	948

The explanation for these fluctuation probably lies in the occurrence of 2 partially overlapping generations one having its peak at the end of September and the other 20 days later. After this although egg-laying may have continued (cf. table 31) it was on a small scale.

In other treatments spraying was imposed on this pattern of generation with results given in table 32.

Table 32

The effect on whitefly numbers of repeated application of DDT—Remeitab Block, 1953.

The effect of DDT spraying on adult whitefly expressed as percentage increase or reduction in numbers in relation to counts taken before and 2-7 days after spraying.

Spraying Date.	% increase or reduction	Date of observation
28 September	—78%	30 September
6 October	+540	10 October
9 October	+617	10 October
	+2259	16 October
13 October	+6700	16 October
13 October	+160	16 October
21 October	—94%	23 October
21 October	—94%	23 October
27 October	—42%	4 November
	+136	17 November
28 October	+490%	4 November
30 October	+240%	4 November
	+2000	17 November
4 November...	+130%	17 November

Reduction in numbers of whitefly adults were obtained from the spray on 28 Sept. and from the sprays applied between 21st. and 27th October. Between 6th and 13th October the results of spraying were increasingly ineffective in reducing numbers of adults, although enormous numbers of dead adults could be seen after such sprays.

The sprays which reduced numbers of adults whitefly coinciding with the 2 postulated population peaks. Nymphal counts, inadequate for detailed analysis were suggestive (table 33).

Table 33

The effect on whitefly numbers of repeated application of DDT.

Remeitab Block 1953.

The effect of DDT spraying on the survival of immature stages of whitefly : based on egg and nymphal counts on 3 microscope fields of 100 leaves.

Date.	Unsprayed		Sprayed once.		Sprayed twice	
	Eggs	Nymphs	Eggs	Nymphs	Eggs	Nymphs
Sept. 21-25	1860	—	1391	—	1336	—
October 1		1085		1342		—
October 10		778		—		1098
A : Oct. 1		57%		97%		
B : Oct. 10		42%				82%

A — Percentage survival of eggs after 7 days.

B — Percentage survival of eggs after 17 days.

Eggs recorded on the plant between 21 and 25 September might be ready to hatch or be newly laid. On 1 October a similar number of nymphs could be expected in the absence of mortality. A comparison of numbers of nymphs on sprayed and unsprayed treatments, in relation to the previous egg-laying recorded, provides a measure of the survival of the eggs. This is shown in line A of table 33, where it will be seen that while only 57% survived in unsprayed, 97% survived in sprayed treatments. A similar conclusion could be drawn from examination on 10 October when the same eggs would have developed into late instar nymphs or pupae.

In the unsprayed treatments there is a mean survival of 42% compared with 82% in the sprayed treatments.

Both these measures indicate that survival of immature stages is about doubled by DDT spraying, a finding which approximates closely with that revealed by general analysis of the adult counts.

Conclusions

It is concluded from these experiments that the commercial application of DDT by aircraft as a single spray in jassid control can almost double the whitefly infestation in a crop. This increase in whitefly occurs in spite of the very high mortality amongst adults which the application of DDT causes, and is a result of the failure of the spray to destroy the immature stages of the insect. On the contrary the survival rate of immature stages is almost doubled by spraying and it appears that this increased survival alone accounts for the increase in whitefly infestation which follows a single spray.

No data are at present available to indicate whether the increased survival rate of immature stages which follows the application of DDT results from changes in the biological or physical environment. There is, however, circumstantial evidence that nymphal survival is increased by the destruction of the parasite *Eretmocerus* sp., although other factors may also be involved.

The Effect of Whitefly on the Cotton Plant

Layout

The following treatments were applied on a single angaia in an unreplicated experiment :—

Cotton	:	X1730A O N
Treatment I	:	Unsprayed
Treatment II	:	Sprayed to run-off with parathion (Pestox 202) as an 0.25% soln. on 3, 17 and 29 Oct. and 17 November.

Counts of whitefly, jassids and bollworm were made at regular intervals and plant diagrams constructed during October, December and January.

Effect on whitefly

The incidence of whitefly was low. Complete control was not achieved, but egg-laying on the sprayed treatments was reduced to half that on the unsprayed during October and the first half of November. Nymphal infestation was reduced by 30% during the same period. Infestations in November were so low that counts were discontinued. The incidence of bollworm was low and these insects are not considered an important factor in the experiment.

Effect on vegetative growth

The small differences in plant height and number of leaves per plant recorded in early October were in favour of the unsprayed treatments. By mid-December the sprayed plants were 13% taller and possessed 46% more leaves, owing to both increased leaf production and decreased amount of shedding. Heights in January were the same as in December, but the number of leaves present were the same in both treatments due to a much higher rate of shedding during the period in the sprayed treatments.

Effect on fruiting

No differences in fruiting behaviour could be detected in early October. By December the sprayed plants supported slightly more sympodial branches but 20% more fruiting nodes had been produced and retained than on the unsprayed plants. In January differences were even more striking. The unsprayed plants showed a reduction in numbers of sympodial branches by 20%. This was due to loss by shedding of branches largely between the 11th and 21st nodes; other nodes were little affected. Fruits were shed with the lost branches and the plants in January supported 20% less fruits. This loss of branches and fruit did not occur on the sprayed plants, which between December and January increased their number of sympodial branches and total fruits by 10%. Thus in January the branches, fruiting nodes, total fruit, buds, green and open bolls were greater by 40, 45, 30, 100, 30 and 300% respectively than on the unsprayed plants.

These results confirm those obtained during the previous season when it was found that there were no measurable differences in the vegetative or reproductive growth of infested and uninfested plants during the first four months of plant growth during which period alone whitefly are present in important numbers on the crop. Differences in growth of infested and uninfested plants were however again apparent during the second four months of plant-growth. In the present experiment final yield figures were not taken but the destruction of whitefly by repeated spraying with parathion advanced the date of maturation of the crop. This is in contrast with the results of the previous season when maturation appeared to be delayed by this treatment, a result considered to have been affected by severe infestation by *Heliothis*.

Amongst other observations carried out the following conclusions were reached by Mr. D. G. Pollard :—

(a) Chlorotic spotting of leaves infested with whitefly was found to be associated with the presence of whitefly nymphs and considered to be caused by destruction of chlorophyl by whitefly saliva.

(b) Magenta spotting of leaves : this was found to be caused by the development of anthocyanins pigment in the chloroplasts. A significant correlation between the incidence of magenta spotting of leaves and whitefly nymphs was found, and the nymphs may be one cause of the development of this spotting.

(c) Leaf shedding : a significant correlation between whitefly nymphs and leaf-shedding was found ($r=0.57$ and $t=6.5$).

(d) Reduction in growth rate : the height of a cotton plant was found to be negatively correlated with the population of whitefly nymphs supported by it. ($r=0.65$; $t=7.5$). The leaf area was negatively correlated with the number of nymphs ($r=0.495$: $t=5.3$). There was no correlation between the total leaves produced and the number of whitefly. All these results are based on values of (t) which are significant at less than the $p=0.01$ level.

(e) Feeding of whitefly nymphs : examination of infested leaves by means of serial sections showed that in 82% of the cases the stylets ended in the phloem and in 16% of the cases in the parenchyma, in one case only did the stylets end in the xylem. It is concluded that nymphs normally feed on the contents of the phloem.

Some Aspects of the Ecology of the Cotton Whitefly

The effect of watering interval on the incidence of whitefly

An experiment was carried out in cooperation with the Chief Agronomist. The following treatments were applied :—

Cotton : X1730A

Sown : 15 August 1953.

Treatments : I. Normal watering (10 day intervals)

II. watering at 7 days intervals.

III. ,, at 21 ,, ,,

IV. ,, at 28 ,, ,,

Each treatment was applied to sub-plots consisting of 5 rows in an angaia ; the 2 outer rows were regarded as belts and excluded from the experiment and observations were confined to plants in the central row. The treatments were randomised in blocks and replicated 4 times in the angaia, each block being surrounded by a belt of lubia.

During September and early October samples consisted of 10 leaves collected at random from each treatment in each replicate, one leaf per plant being taken. In late October and November a similar size leaf-sample was collected but leaves were taken from the 3rd and 7th youngest nodes of each of 5 plants in each treatment of each replicate. From each leaf 5 discs each measuring about 1 sq. cm. were cut and the immature whitefly counted under a miscroscope and recorded as eggs, larvae and pupae (living, dead and parasitised).

Whitefly populations were comparatively high in September and early October, but in mid-October began to decline in all treatments. By early November only inconspicuous numbers were present throughout the experiment (table 34). The greatest number of eggs and other immature stages were recorded on the cotton watered at 7 days, and the lowest number on cotton watered at 28 day intervals. In table 35 numbers are expressed as percentages of those recorded in samples from treatment 1, normal watering. Shortening the watering interval to 7 days was accompanied by an increase of 30% in the recorded number of whitefly stages in the samples. Lengthening the watering interval to 21 days and 28 days gave a decrease in the samples of 35% and 46% respectively. The changes were due almost entirely to a changed amount of oviposition on the different treatments. If the proportion of nymphs to eggs is taken as an indication of the rate of survival it is found to be approximately the same (26-28%).

Table 34.

Whitefly populations in relation to watering intervals.

(Number per 100 sq. cm. of leaf surface). G.R.F. 1953.

Treatment	Stages	Date of Count					Total
		26-27 Sept.	3-4 Oct.	10-11 Oct.	15-17 Oct.	11 Nov.	
I	Eggs ...	789	460	711	448	24	2,432
10-day intervals ...	Nymphs ...	272	118	155	368	24	937
	total ...	1,061	578	866	816	48	3,369
II	Eggs ...	1,362	575	650	538	50	3,175
7-day intervals ...	Nymphs ...	474	123	181	371	50	1,199
	Total ...	1,836	698	831	909	100	4,374
III	Eggs ...	557	496	467	197	11	1,628
21-day intervals ...	Nymphs ...	48	166	101	217	26	558
	Total ...	605	662	468	414	37	2,186
IV	Eggs ...	428	307	265	318	0	1,318
28-day intervals ...	Nymphs ...	58	114	92	215	25	504
	Total ...	486	421	357	533	25	1,822

Table 35.

Whitefly population in relation to watering intervals G.R.F. 1953.

(Totals recorded in samples between September and October expressed as a percentage of treatment 1).

Treatment	Eggs & nymphs	Eggs	Nymphs	Per cent of population as eggs.
I. Normal watering ...	100	100	100	72
II. 7-day interval ...	130	130	128	73
III. 21-day interval ...	65	67	60	74
IV. 28-day interval ...	54	54	54	72

The treatments may be considered in two groups, the well watered (treatment I and II) and the lightly watered (treatments III and IV). The eggs and nymphal counts taken in the two groups are shown in table 36.

Table 36.

Whitefly populations in relation to watering intervals G.R.F. 1953.

(Number per 100 sq. cm. leaf: in brackets percentage of total recorded).

Stage	Treatments	Date of Counts. 29 Sept.	3 Oct.	10 Oct.	17 Oct.	11 Nov.	Total
Eggs ...	Well watered ...	2,151 (39)	1,035 (18)	1,361 (23)	986 (18)	74 (2)	5,607 (100)
	Lightly watered ...	985 (34)	803 (27)	632 (21)	515 (18)	11 (10)	2,946 (100)
Nymphs	Well watered ...	746 (35)	241 (11)	336 (16)	739 (35)	74 (3)	2,136 (100)
	Lightly watered ...	106 (9)	280 (25)	273 (23)	432 (38)	51 (5)	1,142 (100)

In the well watered group two peaks of egg-laying were recorded namely on 29 September and 10 October. Corresponding to these two peaks of egg-laying, two peaks of nymphal counts were recorded. namely on 29 September and 17 October. These peaks are probably a result of 2 partially overlapping generations; the first recorded may be called the September and the second the early October flight of adults. When counts began the former was declining and the latter beginning to emerge (cf. decline in nymphal counts between 29 Sept. and 3 Oct.). The egg-laying of the early October flight was considerably less than that of the September flight and the generation which it produced failed to be breed further on cotton.

Comparing this pattern of generations with that on the lightly watered groups it will be seen that the generations are much less distinct. The September flight laid less than half as many eggs on the lightly watered than on the well watered treatments, and the development of the October generation appeared to be slower so that the two became inextricably mixed. Nevertheless the same decline occurred in both groups in November.

It is clear that while increased whitefly populations can be produced by shortening the watering interval, this factor alone cannot prevent a general decline in numbers which is determined by some other over-riding factor.

The preferred environment offered by prostrate plants

In the course of general observations it was noted that plants which had become prostrate, either through damage or from other causes, carried a considerably higher infestation than plants which are erect even if the two were growing in the same plant hole. In table 37 are recorded counts taken on 28 October from a striking example where an erect and prostrate plant were growing in the same plant hole.

Table 37.

Infestation of whitefly on prostrate and erect plants.

Abdel Hakim 1953.

(Mean infestation per leaf from a sample of 5 leaves)

	Erect	Prostrate
Eggs	428	12,946
Nymphs	66	3,445
Adults	3	71
TOTAL	497	16,462

In a series of examination results summarised in table 38, were obtained which are the mean infestation per leaf taken from 10 erect and 10 prostrate plants.

Table 38.

Infestation of whitefly on 10 prostrate and erect plants.

(Mean infestation per leaf)

Node	ERECT			PROSTRATE		
	Eggs	Nymphs	Total	Eggs	Nymphs	Total
3rd	105	93	198	275	101	376
7th	87	350	437	301	335	636
Total	192	443	635	576	436	1,012

In this series the nymphal counts were similar but the prostrate plants carried 300% more eggs.

It was clear that prostrate plants were preferred for oviposition, but no data were available to determine if survival was better on the prostrate than on the erect plants. Some observations were therefore begun to find out if it were the physical or the biotic environment provided by the prostrate plants which was more favourable.

To test the physical environment offered by the prostrate habit potted cotton plants were placed in a very heavily infested lubia plot. Two plants were placed erect so that all leaves were exposed to the free atmosphere, and two plants were placed prostrate within the lubia crop so that their leaves were near the ground and sheltered from the free atmosphere by lubia crop. Counts made after 10 days, and demonstrated a preference by the whitefly for oviposition under sheltered conditions (Table 39).

Table 39.

The effect of shelter on whitefly numbers.

G.R.F. Nov., 1953.

Number per 100 sq. cm.

Treatment	Counts on 10th Day		
	Eggs	Nymphs	Total
Erect	6	—	6
Prostrate: Sheltered	138	6	142

In these counts 98% of the eggs found on the prostrate plant were on leaves from the four youngest nodes and 100% of the eggs found on the erect plant were from leaves of the oldest nodes, namely the 6th and 8th nodes which were lying within the lubia crop.

It appeared therefore that the environment of a prostrate plant was more favourable to whitefly because of physical factors.

Distribution of whitefly in a crop

A heavy infestation of whitefly developed in plot 129 at the G.R.F. causing serious defoliation in December. It was found that the serious infestation was almost completely confined to July sown cotton. These lay to the centre of the eastern edge of the plot. Nevertheless, the southern edge of the sub-plot were more severely infested than the northern and shelter from wind appeared also to be a factor.

To test the effect of sowing date, exposure to sun, and shelter from wind, leaf samples were taken from various situations in the crop. The number of whitefly counted on these samples are summarised in table 40.

An analysis of variance was carried out on the logarithms of these figures. The analysis showed that differences in total number of immature whitefly recorded on July and August sown cotton and in the 3 main sites (exposed, sheltered, high and low) was highly significant. There was no interaction between site and sowing date.

Table 40.

Distribution of whitefly in relation to sun, wind and sowing date.

G.R.F. December 1953.

(Mean infestation per 100 sq. cm.)

(Samples taken from 3rd, 7th and 12th youngest nodes)

Site	Whitefly Stages.				per cent increase over exposed August sown.
	Eggs	Nymphs	Parasitised pupae	Total	
Exposed to wind:					
High on plant (Main stem).					
July sown	433	161	20	614	490
Aug. sown	113	13	—	126	100
Sheltered from wind.					
High on plant:					
July sown	5,460	4,620	73	10,153	8,000
Aug. sown	460	410	30	900	740
Low on plant (Monopodia):					
In sun (July sown ...	20,400	9,980	110	30,490	23,800
(Aug. sown ...	3,510	2,540	230	6,280	5,000
No sun (July sown ...	8,260	2,790	790	11,840	9,400
(Aug. sown ...	750	220	10	980	780

It is clear that the incidence of whitefly is violently affected by several factors, which include sowing date, shelter, proximity of leaves to the ground, and sunshine. A further analysis of the data was made and the results are summarised in table 41.

Table 41.

The effect of various factors on the incidence of whitefly
G.R.F. December 1953.

(Expressed as percentage increase)

Factor.	Sowing Date.		Mean
	July	August	
Sowing date :			
July	—	—	640
August	—	—	100
Sheltered :			
Exposed	100	100	100
Sheltered	2,850	1,830	2,700
Proximity to ground :			
High	100	100	100
Low (all)	208	390	244
Low (in sun)	300	675	332
Sunshine :			
No sun	100	100	100
In sun	257	640	286

The analysis demonstrated the overwhelming importance of shelter in the whitefly environment, infestations being nearly 25 times larger in sites where the insect was protected from the wind than in sites exposed to the wind. The next factor of importance was sowing date, infestations in all sites being over 6 times greater in July than in August sown cotton. Nevertheless the mean infestation on August sown cotton under exposed conditions, and in the most favourable site (near the ground, sheltered from wind but exposed to the sun) the infestation on August sown cotton was over 10 times greater than on July sown cotton under exposed conditions.

Infestations on young monopodial leaves low down on the plant were twice as great as those on main stem leaves higher up on the plant, but nevertheless sheltered from the wind. If the leaves of the low monopodial growth also enjoyed the sunshine they carried infestations nearly 3 times larger than monopodial leaves of a similar level and age which were shaded.

Proximity to the ground and availability of sunshine seemed relatively more important in August than in July sown cotton, but the interaction of site and sowing date was not significant.

In the same plots counts were taken from plants growing in the belts separating the sub-plots. Whereas the sub-plots had been uniformly treated with 2N fertiliser, the belts had ON. The belts were all well sheltered by the tall cotton of the treatments, and in the absence of N the cotton was small and provided little shade. The early sowing date provided a better environment for whitefly than the late sowing date in the ON as in the 2N series. The effect of shade from the sun was negligible.

The overwhelming importance of shelter from wind is demonstrated by the presence of over 17 times as many whitefly on the ON plants under sheltered conditions than on the 2N plants under exposed conditions.

Table 42.

Effect of nitrogen fertiliser on whitefly numbers

G.R.F. December 1953.

(Exposed as percentage increase)

Factor.	2N	ON
Sowing date:		
July	640	140 (820)
August	100	17 (100)
Sunshine:		
Sun	257	61 (108)
No sun	100	57 (100)
Shelter from wind:		
Exposed	100	—
Sheltered	2,700	1,750

Another factor that emerges from the analysis is the importance of the site of oviposition. Under exposed conditions 50% of the eggs recorded were found on the older leaves (7th and 12th nodes). Under sheltered conditions only 12.5% were recorded on these leaves, the bulk of the eggs being found on the youngest (3rd node). Given suitable shelter, adults preferred to oviposit on young leaves. Furthermore, under suitable conditions of shelter $2\frac{1}{2}$ times as many eggs were laid on a young leaf (3rd youngest node) which enjoyed the sun as compared with a leaf of the same age which was constantly shaded. At the same time the proportion of eggs to nymphs was twice as great on the shaded leaves as on leaves exposed to sunshine, suggesting that the survival of nymphs was affected by the absence of sunshine.

To test the validity of this a series of counts were taken on a spacing trial (Plot 241 — table 43).

Table 43.

Oviposition and nymphal mortality of whitefly.

G.R.F. December 1953.

(Nos. per 50 sq. cm. of leaf surface).

Site.	Whitefly Stages					% mortality of nymphs
		Nymphs				
	Eggs	Alive	Dead.	Parasitised.	Total	
Main stem :						
3rd and 7th youngest leaf						
Exposed to sun and wind...	14	27	10	1	38	25
Sheltered from wind ...	50	60	6	2	68	10
15th Node :						
Exposed to sun	20	65	6	1	72	10
Sheltered from sun ...	10	45	66	5	116	50
Sympodia :						
Young unshaded leaves	102	139	21	17	177	10

In this case spacing was very wide (100 x 160 cm.) and little shelter available. The bulk of the eggs recorded were from sympodial leaves (monopodia not being sampled). Relatively few were laid on main stem young leaves except where there was wind shelter. Some eggs were laid low down on the plant on older leaves (15th oldest nodes) at about the same level as the sympodial leaves selected. Survival, as measured by the percentage of live nymphs out of the total of nymphs recorded, was the same on sympodial leaves, young leaves sheltered from the wind and old leaves exposed to the sun, but considerably less on old shaded leaves.

It is tentatively concluded that oviposition is favoured by shelter from the wind and exposure to the sun, but that the former is a more powerful factor than the latter. When wind shelter exists in the crop, a larger proportion of the eggs are laid on the uppermost leaves. When no shelter exists in the crop a larger proportion of the eggs are laid on the lower leaves. Survival of nymphs is greater on leaves exposed to the sun (*i.e.* ones that are fully active photosynthetically).

It should be noted that shelter from wind (tables 40 and 43) and shelter from wind and sun (table 40) favours parasitism of whitefly nymphs. Under the most favourable conditions (absence of wind and sun) parasitism reached nearly 30% of the total nymph populations.

Comparative Evaluatory Tests with Various Insecticides against Whitefly Nymphs

The following experiments are reported by Mr. M. R. Norman.

The Method

Separate generations of whitefly were bred on caged plants grown in petrol tins; without being detached, infested leaves were sprayed on either their lower or upper surfaces. In this way, comparative figures for the contact and translaminar (systemic through the leaf-blade) effect of the sprays against larvae were obtained. The same method was adopted in a series of ovicidal tests.

Pre-spraying counts were taken from entire leaves with appropriately designed equipment. Final checks were carried out not earlier than 9 days after treatments. The initial difficulty of discriminating between the dead and live larvae was overcome.

Tenacity tests with adults were less successful owing to poor recoveries of insects introduced into cages for test purposes.

Results

Parathion at 1 : 2000 (the conc. used in the large scale experiments in the Gezira) killed larvae of all stages by contact and when sprayed on the upper surface of the leaves (translaminar effect). As an ovicide it gave hatch reductions (Abbott's) of 72%, 39% and 19%, depending on the age of egg batches (fresh deposits being the more resistant). Survival of newly hatched larvae was, however, reduced by 60-100%, depending on the interval between spraying and hatching.

Planthion (a wettable powder of parathion) behaved similarly, although it was less effective in contact applications both as larvicide and ovicide. It had a better residual effect against adults and against the larvae hatched from eggs that it failed to kill. It seemed also to possess a certain fumigating effect.

Malathion emulsificate (at 1:500, four times stronger than parathion.)

Contact	:	97%
Translaminar	:	99%
Ovicidal	:	NIL but 100% mortality of newly hatched larvae by residual effect.

With the wettable powder of Malathion the trans-laminar effect was reduced to app. 60%.

C.R. 686 (1:2000) :—

Contact	:	100%
Translaminar	:	40 — 90%
Ovicidal	:	NIL and little residual effect on newly hatched larvae.

C.R. 686 seemed to have a strong fumigating effect.

Diazinon :—

Contact	:	at 1:2000 — 50%
	:	at 1:1000 — 90%
Translaminar	:	at 1:000 — 30%
Ovicidal	:	— NIL but reduced survival by 75%

Of other organic phosphate tests were carried out with C.R. 1112, CR. 1113, NC. 47, Paratox and Pestox 3. Paratox was the most effective material tried this season, being a good larvicide by contact and through the leaf, as well as a good ovicide with a 100% residual effect against the newly hatched larvae.

Both DDT solutions and emulsions were tested at 1:500. The results obtained were identical. Both showed a larvicidal effect, although no other. Their efficacies fell off with the age of the larvae.

2nd. instar	mortalities	— 95 — 100%
3rd. ,,	,,	— 67 — 68%
4th ,,	,,	— 40 — 42%

Pupae were affected so that some adults failed to emerge, whilst many that emerged were killed by the residual effect of DDT on the foliage.

To test if DDT could be used to control whitefly by more efficient application in the field low volume and low pressure spraying (with semi-downpipes) was compared with high volume and high pressure application (using full-length downpipes). A DDT cum Parathion mixture was also included. Results are given below :—

1. DDT emulsion	1 lb. act. ingr/fed. ;	35 gal. ;	50 psi.	33.3%	(Abbott's larval mortality.)	
2. ,, ,,	1 lb. ,, ,,	100 ,,	100 ,,	59.0%	,,	,,
3. DDT/parathion		35 ,,	50 ,,	77.5%	,,	,,

The larvicidal effect shown above is reflected in adult counts taken on successive dates :—

	1 Dec.	3 Dec.	5 Dec.	6 Dec.	14 Dec.	20 Dec.	2 Jan.	12 Jan.
1	138	—	6	9	59	411	231	110
2	169	—	0	20	47	238	154	98
3	159	—	4	18	72	225	151	86
Control	163	—	106	176	183	226	353	121

Spectacular increases in adult populations, in spite of an initial kill, followed low volume downwards spraying with DDT in several experiments carried out this season. It is suggested that removal of parasites is the cause. Similar increases which, however, never went above the control level, were also obtained with parathion. Since this season's records indicate that parasite mortality is greater from parathion than from the explanation lies probably in the fact that a low volume downward spray of parathion, even if not fully efficient, will result in a certain degree of larval control whereas in the case of DDT larval development will proceed unhampered by parasites.

Survey of Cotton Thrips.

Survey.

During August, September and October a survey was carried out by Mr. R. O. Bowley in Hag Abdalla Block of the South Group of the Sudan Gezira of the incidence of cotton thrips on weeds in the fallows. The two major weed host plants *Heliotropium* spp, (Boraginaceae) and *Leucus urticaefolia* Benth. (Labiatae) alone were considered in this survey and no evidence emerged in the work to suggest that findings would have been materially altered if populations on minor host plants had been counted. *Crotalaria* spp. was also found to be a favoured host plant but was not a plentiful weed in the fallows

Adult thrips were first found in 1953 on 8th August on *Heliotropium* sp. Larval counts made during the period 27 August — 19 September indicated that both species must have been present at that date. *Hercothrips sudanensis* was the predominant species on *L. urticaefolia*. Similar numbers of *H. sudanensis* and *H. fumipennis* were found on *Heliotropium* spp. In table 44 is summarised the species distribution on the three weed hosts.

Table 44.

Distribution of thrips species on main weed hosts in fallows.

(Based on larval counts 28 August — 18 September 53)

Percentage of larvae of each species found on

	Heliotropium spp. No. of leaves examined	%	*Leucus* spp. No. of leaves examined	%	*Crotalaria* spp. No. of leaves examined	%
H. fumipennis ...	2,193	55	1,353	2	82	30
H. sudanensis ...		45		98		70

Surveys were made on the incidence, and infestation of, host plants in 5 of the phases of the Gezira rotation during 4 different sampling periods by means of 40 random quadrants each of $\frac{1}{2}$ sq. m. in a 10 feddan plot. Six replicates of each of the 5 phases were chosen at random throughout Hag Abdalla Block. The number of clean and infested host plants recorded are summarised in table 45.

Table 45.

Hag Abdalla Block 1953.

(i) *Heliotropium* spp. recorded in 240 random quadrants each $\frac{1}{2}$ sq. m. in extent.

	Sampling Dates				Total
	27/8-3/9	6-12/9	15-16/9	20-21/9	
Cotton fallow Total ...	248	112	74	40	474
% infested ...	25	54	30	47	35%
Fallow cotton Total ...	22	3	1	0	26
% infested ...	0	0	0	0	0%
Dura fallow Total ...	443	244	26	10	723
% infested ...	20	22	42	0	21%
Fallow dura Total ...	35	20	8	3	66
% infested ...	3	40	12	50	17%
Fallow fallow Total ...	523	127	25	1	776
% infested ...	14	43	8	0	17%

(ii) *L. urticaefolia* recorded in 240 random quadrants each of $\frac{1}{2}$ sq. m. in extent.

	Sampling Dates				Total
	27/8-9	6-12/9	15-17/9	20-21/9	
Cotton fallow Total ...	414	230	75	8	727
% infested ...	5	6	23	25	7%
Fallow cotton Total ...	599	343	35	161	1,138
% infested ...	0	0	0	11	1%
Dura fallow Total ...	1,691	1,243	46	18	2,998
% infested ...	2	6	44	17	4%
Fallow dura Total ...	87	104	56	32	279
% infested ...	2	6	0	3	3%
Fallow fallow Total ...	1,382	1,087	138	9	2,616
% infested ...	4	6	10	0	5%

In the case of *Heliotropium* which provided equal numbers of *sudanensis* and *H. fumipennis* the fallow phases of the rotation (cotton fallow, dura fallow and fallow fallow) supported 95% the host plants and 98% of the infested host plants recorded. Since cotton fallow occupies twice the area of any other fallow this phase must be regarded as a most important as a source of infestation of *H. fumipennis*. In the case of *Leucus* sp. dura fallow and fallow fallow supported 78% of the host plants and 80% of the infested host plants recorded. These phases of the rotation must be regarded as a most important source of infestation of *H. sudanensis*.

The total life-cycle of both species of thrips occupies 17-30 days and observations suggested that during August and September 1953 two generations were completed on weeds.

Thrips were first observed on cotton in August as soon as germination had occurred. Larvae were first found on 9 September. Large numbers of adults were observed on cotton between 15-17 Sept. a period during which drying out of the weeds (see table 45) was observed to have been accompanied by thrips flight. Weed counts recorded in table 45 suggest that drying out of the weeds must have been completed by the end of September and after which date no further invasion of cotton by thrips is likely to have occurred. By this date the mean percentage of leaves infested with thrips larvae in samples each of 500 leaves taken from 30 plots was 9%. Subsequent build up of populations in cotton was prevented by various spray treatments, but numbers were recorded in unsprayed treatments in a neighbouring Block (Remeitab) were a peak infestation in which 34% of the leaves were infested with thrip larvae, was recorded in early November. It is inferred therefore, that, during 1953 the bulk of the damage to cotton was due to thrips that had bred within the crop after colonisation had been completed. Peak populations of *fumipennis* were recorded in October and of *sudanensis* in November.

V. Investigation of Spraying Techniques.

Introduction

Following the encouraging results during the 1952/53 season when control of cotton jassids at least equal to that achieved by conventional methods was obtained over a swath of 75 m. when a DDT spray was drifted from an air-blast Micron Sprayer, investigations were carried out in the Gezira during the present season to determine whether the drift technique could be adopted for use in routine spraying against the cotton jassid.

Some preliminary trials were carried out in U.K. where, with the help of the National Institute of Agricultural Engineering, some information was obtained on the range of droplet sizes and the dosages achieved across a swath of 300 m. when sprays were applied by the standard nozzle equipment of Pest Control Ltd. (swirl-nozzles), and that of Aerial Spraying Contractors (Alexander nozzles).

Following these results a large scale experiment was carried out in the Gezira from which the following information was sought :—

(a) The drop spectrum when a 25% DDT concentrate was applied by aircraft using standard nozzle equipment under Gezira conditions in October.

(b) The distribution of DDT deposits across swaths of varying widths.

(c) The control of jassids achieved by applying spray concentrates over varying swaths.

Experiment in Drift Spraying

Layout

The following treatments were applied to Domains Sakel cotton in Um Degarsi Block of the northern Gezira.

1. Attempted swath 140 m.
2. ,, ,, 70 m.
3. ,, ,, 40 m.
4. ,, ,, 20 m.

An unsprayed control treatment was disallowed by the S.G.B. but observations were made on the single unsprayed cotton Number of the Block. Each treatment was applied to half a standard 90 feddan cotton Number so that plots were 40 or 50 feddan each. The Numbers measured 280 m. across their width, and were divided into 14 parallel strips (angaias) each of 20 m. The swaths were achieved by 2, 4, 7 and 14 aircraft runs respectively for treatments 1, 2, 3 and 4. The whole was replicated 5 times thus using 1800 feddans of cotton.

Treatments were applied by Auster J.5. G. aircraft fitted with a 36 ft. boom spraying undiluted psyllortox 250 (a proprietory DDT emulsion containing 25% active ingredient) by swirl nozzles of varying types to obtain outputs of approximately 12, 6, 3 and 1.5 gals. spray per minute for treatments 1, 2 3 and 4 respectively. The various swaths were achieved by calculating the correct height of flight to be used in relation to the velocity of the effective cross-wind, so that a constant product of height (in feet) and wind speed (in m.p.h.) was achieved for each treatment. The attempted H.U. (height x wind speed) was 400, 300, 150 and 60 for treatments 1, 2, 3 and 4 respectively.

Jassid control

The two central 10 feddan holdings in each plot were used for assessment of jassid control In these fields a pre-spray and 4 post-spray assessments, each at 10 day intervals, were made by counting the total number of jassid nymphs recorded on 100 leaves selected at random from 20 plants in each angaia. Thus on each occasion the jassid numbers on 2800 leaves were counted in each of the 20 plots (4 treatments x 5 replicates). The pre-spray and the mean of the post-spray counts recorded in each treatment are given in table 46.

Table 46.

Um Degarsi 1953.

Jassid control by aerial drift spraying.

(Jassid nymphs per 100 leaves)

Attempted swaths in metres

Jassids.	140	70	40	20	S.E.	L.sig.diff. P=0.05
Pre-spray	75.8	63.9	71.7	57.0	±8.76	32.31
Mean post-spray ...	21.5	3.4	4.0	1.7	±2.74	8.25
Yields k.p.f. ...	4.57	4.84	4.64	4.79	±0.30	0.91

Note : (a) Pre-spray jassid count is the mean of a single count taken 1-2 days before spraying. The post-spray count is the m an of 4 counts taken at 10 day intervals during 6 weeks after spraying

There were no significant differences between jassid populations before treatments were applied and an analysis of co-variance shows no correlation between yield and pre-spray jassid numbers (r=-0.2333 ; not significant). The jassid control achieved by all treatments was good the mean number of jassid nymphs recorded per 100 leaves during 6 weeks after spraying being 7.6 compared with 219.6 on the single unsprayed cotton number and 3.0 nymphs per 100 leaves on cotton sprayed commercially. The control achieved by treatment 1 (140 m. swath) was inferior to that achieved by the other spray treatments the post-spray jassids counts being greater at all levels of significance.

This inferior control by treatment 1 was not reflected in yields which did not differ significantly in any treatment. An analysis of co-variance of yield and post-spray jassid infestation showed no significant correlation (r—0.2501 : not significant).

Spray distribution

Approximately 600 microscope slides (3″ x 1″) treated with silicone were placed on a single replicate of each treatment; each slide was numbered and placed in an exposed position on the soil of the ridges separating the angaias. The slides were removed the day following spraying. Owing to mud splash from rain which fell during the night and droplets of honey dew from whitefly in the crop it was necessary to brush each slide gently with a camel hair brush to remove soil particles and then soak each in water for 15 minutes to remove the honey dew. After this process a greater number of spray droplets could be seen than previously. Each slide was examined by projecting the image of the droplets onto a screen by means of lens and the droplets classified in size groups of 50 microns range. The spread factor of this formulation on silicone treated slides had already been calculated. The droplets were classified under the heading of the upper limit of the group into which they fell. From these figures the mass median diameter (MMD) of the droplet spectrum was deduced graphically after converting the droplet mid-diameters into cubic-microns.

From these figures it was possible to estimate the drop-spectrum produced by the nozzle arrangement adopted in each of the 4 treatments, the distribution of DDT across the swath and the recovery of DDT on slides placed in exposed positions on the ground.

The MMD of the nozzle arrangement was found to be 370, 340, 300 and 312 microns for treatments 1, 2, 3 and 4 respectively. The main bulk of the volume of spray recovered however (namely 70-85% of the recovered spray) fell within the droplet ranges of 208-584, 135-565, 135-500 and 100-450 microns respectively for treatments 1, 2, 3 and 4. These ranges are important because from them it is possible to calculate how closely the swath achieved approximated to theoretical expectations derived from the HU employed in each treatment. The distribution of DDT recovered across the swath is shown in table 47.

Table 47.
Um Degarsi 1953
Distribution of DDT across swaths.
(in lbs./feddan)

Distance (m) from point of application	TREATMENTS			
	1	2	3	4
20	3.12	2.37	0.54	0.72
40	1.32	2.30	2.89	—
60	0.25	1.87	—	—
80	0.10	1.08	—	—
100	0.15	—	—	—
120	0.09	—	—	
140	0.09	—	—	—
Mean	0.73	1.95	1.71	0.72

In treatment 2 and 3 the ground recovery of DDT was more than 100%. This was probably due to the irregular overlapping of swaths, but might also indicate errors in the estimation of deposits by the method used.

Jassid control in relation to spray distribution

Averages were made of the mean post-spray counts of jassid nymphs recorded in each 20 metres of the swaths in 4 counts during 38 days following spraying. These are shown in table 48.

Table 48.

Um Degarsi 1953

Post-spray distribution of jassid nymph across swaths.

(Mean numbers per 100 leaves recorded in 4 counts taken during 38 days after spraying).

Distance (m) from point of application.	Treatments.			
	1	2	3	4
20	2.6	1.00	2.3	2.2
40	3.5	1.0	5.5	—
60	5.9	1.0	—	—
80	11.1	2.25	—	—
100	16.2	—	—	—
120	18.6	—	—	—
140	15.9	—	—	—
Mean	10.5	1.3	3.9	2.2

The mathematical relationship of post-spray jassid numbers and estimated deposit of DDT across the swath has not been calculated, but when these two factors are plotted graphically it can be seen that where deposits are greater than 0.5 lb. of DDT per feddan the post-spray infestation never exceeds 6, and exceeds 2.4 nymphs per 100 leaves only twice out of 15 occasions. When deposits of less than 0.5 lbs. DDT per feddan were recorded post-spray jassid counts ranged from 0.25 to 31.6 nymphs per 100 leaves. The mean number of nymphs recorded during 6 weeks after spraying on parts of swaths receiving more than 0.5 lbs. DDT per feddan was 1.0, and on parts receiving less than 0.5 lbs. was 10.0 The counts therefore suggest that 0.5 lbs. DDT per feddan was a critical dosage for control under the conditions of experiment.

Conclusions

The following conclusions have been reached from the experiment :-

(i) The application of an undiluted 25% emulsion of DDT at 0.4 gals. spray per feddan can give an entirely satisfactory control of cotton jassids, over a period of 6 weeks after spraying. The results being in no way inferior to the present standard practice in the Gezira.

(ii) Application of spray by aircraft can be assisted by spray drift on cross-winds. When the attempted swath was 70 and 40 metres control was in no way inferior to that achieved by the standard practice of 20 metre swath. Increases in swath to 140 metres resulted in a significantly inferior control of jassids.

(iii) The crop can tolerate a considerable range of post-spray jassid infestation (during November) without any measurable effect upon yield.

(iv) It is possible to relate the degree and persistance of control to the recovery of DDT within the crop.

SOIL RESEARCH SECTION.

by T. N. Jewitt

Introduction.

The senior members of the Section are T. N. Jewitt, K. R. Middleton, T. G. Wasowicz, Mohammed Abdel Aal and C. W. Mitchell.

The principal soil survey of the season has been in the Gezira, where 450 holes were dug, virtually completing the survey of all areas likely to be irrigated. A long reconnaissance survey was made from Wad Medani to Equatoria, soils being examined at Malakal (for rice), Mongalla (for sugar) and Lafon (for dura). The clay soils of the Sudan vary greatly in hardness and, though they all crack, some afterwards fill in their cracks by fragmentation of the crack edges while in others the cracks remain wide open. Samples of a range of soils were collected with this in mind and will be examined to see if the soft, self-mulching soils can be distinguished in the laboratory from the hard persistent-crack soils. In the Gezira interesting results have been obtained with gypsum blocks used to study soil moisture.

A good deal of information about Sudan soils has been collected from reports and publications and embodied in a general manual of soils of the Sudan.

Meteorology.

The usual supervision of the seven Gezira stations has continued. Data for the Gezira Research Farm are on page 6.

Soil Survey.

Blue Nile Province (Goda).

The Goda scheme referred to in the last year's report was established this year on the land recommended. The indications are that the first year's crop will be good and bear a marked relation to the sodium value of the soil. An extension to this scheme to replace the land rejected on the basis of last year's survey has been examined.

Blue Nile Province (Zuleit)

This area is almost opposite Goda on the west bank of the Nile. The results of the survey are as follows :—

Table 1

Na Value Range	No. of Holes	Na Value Range	No. of Holes
0– 5	5	41–45	50
6–10	3	46–50	35
11–15	16	51–55	17
16–20	5	56–60	12
21–25	30	61–65	10
26–30	28	66–70	2
31–35	32	greater than 70	3
36–40	33		

This scheme was established before the soil survey was done, and the quality of the land is considered to be poor. The scheme has made a bad start and it will be interesting to see what degree of success is eventually achieved on this land.

Equatoria Province (Yambio)

A sample area was investigated in detail to see what soils were recognizable in the field. The area chosen was the Research Farm itself because detailed contours exist for this. There are broad catenary soil groupings in Equatoria, but it is doubtful if these are regular enough to be used usefully in soil survey except in the broadest possible way. The type of survey used in the present work was undertaken to see, in a sample area, how complex the soils were. The samples were taken in a grid system with holes 100 — 150 m. apart. It was possible to divide the soils into 6 units, each of which included a considerable range, but all of which were distinguishable in the field. The units occurred in sufficiently large patches to enable them to be put on a map.

Laboratory examination of the samples has revealed no substantial chemical differences between the soil units.

Reconnaissance Survey

The main purpose of this survey was to collect surface samples of clay soils showing contrasted degrees of surface hardness and friability. These have not yet been examined in the laboratory. Although these marked differences in surface friability may not be so important during the rains when the soils are wet, it is difficult to believe that important agricultural differences are not associated with them.

Two quite different soils in the plains of Upper Nile Province were examined, one under *Balanites aegyptiaca* and grass park land and the other pure grass. Both soils are subject to extensive flooding and their difference may well be due to differing origins.

Between Gemmeiza and Mongalla on the upper White Nile several lines of holes were dug for as far as 15 km. inland. These showed an interesting succession of soils associated with marked vegetational changes.

Coffee soils were examined in Yei district with the Coffee Officer. It appears that the encouragement of deep rooting of coffee is of prime importance. It is possible that planting in deep holes with prepared soil might be a means of influencing depth of rooting.

Soil Exhaustion in Kordofan Gozes.

An interesting set of samples was taken by Mr. J. S. Manton from two sites on the sand soils near Umm Ruaba. One site was in an area which had been cultivated for a long time and the other in a nearby forest reserve, which had not been cultivated for 30 years and carried a good stand of gum (*Acacia senegal*). The area of each site was 2 feddans and 10 holes were dug in each and sampled in 6 in. steps to 2 feet. Table 2 below gives some of the laboratory determinations expressed as mean values for over-cultivated and forest reserve sites :—

Table 2

	Six Inch Step.			
	1	2	3	4
pH				
Exhausted Land	6.4	5.5	5.2	5.2
Forest Land	7.6	6.9	6.7	6.3
Organic nitrogen p.p.m.				
Exhausted Land	90	85	75	65
Forest Land	190	140	125	110
Exch. Ca. mg e/100 g. soil.				
Exhausted	0.65	0.65	—	—
Forest	1.1	1.3	—	—

The validity of the above comparison requires that the two sites should have basically similar soils. The clay contents given below suggests that this is the case.

Mean Clay Percentage.

	Six Inch Step.			
	1	2	3	4
Exhausted Land	5	9	10	11
Forest Land	6	8	10	10

The colours of the samples differed regularly, the over cultivated plot surface soil being 2.5YR. 6/8, and the 18-24 inch samples 2.5YR. 5 8. The corresponding colours of the forest samples were 5YR. 6 8 and 2.5YR. 5 8.

Um Ruaba (12° .53′ N — 31° .13′ E) is on the railway and has permanent water, and largely on account of this has suffered severe over-cultivation for many years. The cultivated sites in this comparison are believed to have been continuously cropped for the last 30 years. An attempt was made to demonstrate the differing fertilities of the two sites. Several crops were used and N.,P. and K were applied to some of the area.

The mean yields (in rotls per feddan) of all treatments for sesame and groundnuts (unshelled) were 105 and 416 on the exhausted soil, and 270 and 600 on the forest soil. On the unmanured subplots sesame yields were 52 and 270 on the exhuasted and forest soils respectively.

Moisture Studies with Gypsum Blocks.

The following table summarizes readings of log. resistance obtained with gypsum blocks in growing cotton at the G.R.F. The readings given are those taken immediately before irrigation, and the lowest subsequent reading.

Table 3

Log. R Readings of gypsum blocks

Date	Depth			
	12″	24″	36″	48″
13.10	3.9+	3.9+	3.9+	—
14.10	1.4	1.4	1.4	—
27.10	1.6+	1.7+	1.5+	—
11.11	1.7+	3.0+	3.0+	—
		1.7	1.9	
24.11	1.95+	2.9+	3.2+	—
		1.6	3.3	—
8.12	1.9+	2.1+	3.6+	3.2+
		1.7	3.5	2.6
22.12	1.8+	1·9+	3.7+	3.3+
		1.7	3.7	2.6
5.1	2.1+	2.1+	3.9+	3.2+
	1.7	2.0	3.7	3.3
20.1	2.2+	2.7+	3.7+	3.5+
	1.7	2.5	3.7	3.5
3.2	1.8+	3.0+	3.8+	3.6+
	1.7	3.0	3.7	3.6
16.2	1.8+	3.1+	3.8+	3.7+
	1.8	3.1	3.8	3.7
3.3	1.9+	3.3+	3.8+	3.7

12″ 24″ 36″ Blocks installed 13.10.1953.

48″ Block installed 5.12.1953.

\+ Reading just before irrigation

The 12″ block never indicated any considerable drying out of the soil.

The 24″ block showed no appreciable drying during the 1st. irrigation period but during the next two irrigations it showed drying (log. R=3.0 and 2.9). The highest reading during the next three irrigation periods was 2.1, with apparently little drying out. The next four pre-irrigation readings were 2.7, 3.0, 3.1 and 3.3. indicating drying out. Towards the end of the period irrigations failed to reduce the value of log. R, water apparently failing to reach the block.

The reading for the 36″ block reached log. R=3.2 on 24.11 and subsequently slowly increased; at no period after this did irrigation reduce the reading.

The 48″ block after installation had reduced readings after irrigation on two occasions, and after that the resistance increased slowly and steadily. The fact that water reached the 48″ block and not the 36″ one may have been due to penetration through the irregular soil crack system. Generally when irrigation water reached any block it did so rapidly, presumably down cracks, not by diffusion through the mass of the soil.

The readings of the four blocks on 3.3.54 and the slopes of the log. R — time curve suggested that the plants were withdrawing water from around the 12″ block only.

The calibration of the blocks proved difficult; the curve shows a large moisture range where the blocks give a constant saturation reading, with a rapid rise in resistance as the moisture falls below a critical value. There are also the usual hysteresis effects.

The general behaviour of this set of blocks was the same as that of another set (12″, 24″, 36″) in a different cotton plot. This second set was started later on 25.11.53. The 36″ block after irrigation had log. R= 3.5. Subsequent irrigations never reduced this figure which slowly rose to 3.7 on 7.3.1954.

The 24″ block behaved in the same way as the 24″ block in the first set, in that only after 5.1.54 did drying out start, though its ultimate steady rise in resistance took its reading to log. R= 3.7, on 2.3.54 just before an irrigation as against 3.3 in the first set.

The 12″ block on 16.2 and 2.3.54 had log. R readings of 2.6 on each date. The irrigation on 16.2 reduced this reading to 1.7 but that on 2.3 failed to reduce the pre-irrigation reading which on 7.3.54 had reached 3.4. Thus the final readings on this date suggested that the plants had substantially dried the soil round all the blocks. The cotton on this plot was considerably larger than on the first plot.

Soil Nitrates in the 3-Course Rotation Experiment.

This year the two plots under cotton were 14 and 15. They were sampled monthly in six inch steps to two feet. The presowing rains were heavy and, as expected, the nitrates in late August were low. Table 4 gives the nitrate figures measured throughout the year.

Table 4

Nitrates, p.p.m. NO_3—N. Three Course Rotation Experiment

Rotn.	26.5.1953				17.6.1953				15.7.1953			
	Step				Step				Step			
	1	2	3	4	1	2	3	4	1	2	3	4
1. CFF	4	5.5	5.5	5.5	5.5	5.5	6.5	6.5	3.5	6	4	2.5
2. CDF	4	4.5	4.5	3	3.5	4	4.5	4	3	2.5	2	2
3. CDD	1	1	1	1	2	1	1	1.5	1.5	1	1	1
4. CLF	12	17	11.5	7	9.5	12.5	12.5	10.5	6.5	9	6	3.5
5. CDL	7.5	8	7	4	4.5	6	6.5	6	3	6	4	3

	18.8.1953				23.8.1953				16.9.1953			
	Step				Step				Step			
	1	2	3	4	1	2	3	4	1	2	3	4
1. ...	1.5	1.5	1.5	4	2	1	1.5	3	2.5	2	2	3
2. ...	1	1	1	5	2.5	1	1	2.5	2	1	1.5	2
3. ...	1.5	1.5	3	3	2	1	1	2	2	1	1	1
4. ...	1.5	1.5	3.5	5.5	4.5	2	3.5	7.5	4.5	2	2	5
5. ...	1.5	1.5	2	2	3	2	4.5	5.5	9	2	3	5

	21.10.1953				21.11.1953				19.12.1953			
	Step				Step				Step			
	1	2	3	4	1	2	3	4	1	2	3	4
1. ...	2	1	1.5	1.5	1	1	1	1	4.5	1.5	1.5	1.5
2. ...	2.5	1	1	1.5	2	1	1	1	2.5	1	1	1
3. ...	1	1	1	1.5	2.5	1	1	1	2	1	1.5	1
4. ...	3	1	1.5	2.5	2.5	1	1	2	5	1.5	1.5	1.5
5. ...	3.5	1.5	2	3	3	1	1	1	4.5	1.5	1.5	1.5

	27.1.1954				21.2.1954				21.3.1954			
	Step				Step				Step			
	1	2	3	4	1	2	3	4	1	2	3	4
1. ...	2	1	1	1	1.5	1.5	3.5	1	1.5	1	1	1
2. ...	2	1	1	1	1.5	1	1	1	1	1	1	1
3. ...	1.5	1	1	1	3	1	1	1	2.5	1	1	1
4. ...	2	1	1	1	3.5	1	1	1	1.5	1	1	1
5. ...	3	1	1	1	1.5	1	1	1	4.5	1	1	1

The following table compares August nitrates for the last three years and illustrates the differences which are found from year to year.

Table 5.

August NO_3—N 1951, 1952 and 1953.

Rot.	15-18.8.51				22.8.52				18.8.53			
	Step				Step				Step			
	1	2	3	4	1	2	3	4	1	2	3	4
1. ...	11	2.5	4	5.5	8.5	4.5	2	4	1.5	1.5	1.5	4
2. ...	7.5	2.5	3.5	5	7	3	2.5	4.5	1	1	1	5
3. ...	3	1	1	1	3.5	2	1.5	2.5	1.5	1.5	3	3
4. ...	28	9.5	15	10	20.5	6.5	5.5	9.5	1.5	1.5	3.5	5.5
5. ...	11.5	4.5	7	4.5	13	5.5	5	7	1.5	1.5	2	2
Mean ...	12	4	6	5	10.5	4	5	5.5	1.5	1.5	2	4

Presowing rain: 49 mm. (15-18.8.51); 170 mm. (22.8.52); 239 mm. (18.8.53).

This effect is believed to be associated with the washing down of nitrate during the rains. It was shown (Annual Report 1949 50 P. 102) that the top foot nitrate in these plots was negatively correlated with presowing rainfall in rotations 1, 2 and 4.

We have in the figures of table 5 evidence of soil change associated with the presowing rains. It is not one which offers an easy explanation of the beneficial effect of the presowing rain on the yield of cotton.

Analysis of Cotton Leaves.

This investigation is carried out in collaboration with the Agronomy and Plant Physiology Section which does the leaf sampling and supplies the yields. The cotton plants of Plots 14 and 15 were sampled on 29.9.1953. Table 6 gives the oven-dry weights of the leaves of a 20 plant sample, and the percentages of N, P_2O_5.K_2O and CaO in each sample on an oven-dry basis.

Table 6.

Composition of Cotton Leaves. Plots 14 and 15.

Rotation	Sub Plot	Wt. of sample g.	N %	K_2O %	P_2O_5 %	CaO %	Final Yield k.p.f.
1. ...	44	23.9	3.94	1.9	0.84	6.4	5.13
CFF ...	49	28.0	4.35	2.0	0.76	6.0	4.88
	51	28.0	4.72	2.0	0.87	6.4	3.62
	58	32.7	4.24	1.9	0.96	6.1	5.53
Average ...		28.2	4.31	1.95	0.86	6.2	4.79
2. ...	41	23.5	4.32	1.8	0.90	6.4	4.11
CDF ...	50	14.7	3.58	1.9	0.76	5.0	4.26
	55	31.0	4.35	1.9	0.87	6.1	4 54
	56	24.5	3.85	1.9	0.98	5.8	4.45
Average ...		23.4	4.02	1.90	0.88	5.8	4.34
3. ...	42	16.6	3.64	1.8	0.84	5.4	2.19
CDD ...	47	21.3	3.50	1.8	0 89	5.4	2.59
	53	24.5	3 83	2.1	1.02	5.4	2.68
	60	18.0	3.70	1.9	0.96	5.1	2.86
Average ...		20.1	3.67	1.90	0.93	5.3	2.58
4. ...	43	27.6	3.97	2 0	0.81	6.0	5 98
CLF ...	46	37 6	3.93	2.1	0.79	6 0	7.70
	54	42.7	4.24	2.1	0 86	6.1	6.33
	59	49.2	4.11	2.1	0.78	5.7	6.37
Average ...		39.3	4.06	2.10	0.81	5.95	6.59
5. ...	45	33.9	4.32	2.1	0.77	6.2	6.76
CDL ...	48	32.9	4 05	2.2	0.84	5.9	6 84
	52	32.0	3.94	2.1	0.81	5.5	4 91
	57	39.3	4.35	2.0	0.77	6.4	6 77
Average ...		34.5	4.19	2.10	0.80	6.0	6.32

This is the fifth year that cotton leaves at the same age, have been analysed. Table 7 gives some summarized results for these samplings.

Table 7.

Content of nutrients (g./100 plants) in leaves at the end of September, with sample weights, presowing, rainfall and final yields

Year	July 1 to August 15 rain mm.	N g.	K_2O g.	P_2O_5 g.	CaO g.	Sample Wt. g.	Yields k.p.f.
49/50 ...	69	2.7	2.5	0.7	4.4	80	3.6
50/51 ...	180	2.0	2.0	0.6	3.3	65	5.7
51/52 ...	49	5.4	4.3	1.2	8.6	135	3.6
52/53 ...	170	5.6	4.4	1.1	8.9	165	3.5
53/54 ...	239	5.9	2.9	1.3	8.6	145	4.92

These figures suggest that early growth of the plants and uptake of nutrients are not influenced in any regular way by the presowing rains. The yields are difficult to compare because the first two years are without DDT spraying against jassids, and the year 51/52 and 52 53 had conspicuous whitefly damage.

Nitrate in Cotton Plants.

Some preliminary observations were published in Annual Report 1950 51. It is felt that nitrogen nutrition is of prime importance in the growth of cotton in the Gezira. There is however ample evidence that the problem is complex, and so far the relation between soil nitrate and nitrogen uptake has not been solved. From a review of work on nitrates in plants one can draw a fair conclusion that the nitrate N concentration in plant tissues, particularly in young succulent stems and leaf petioles, can be accepted as a good reflection of available nitrogen status and its supply in the soil, and as a better indication of soil nutrient relations than total nitrogen or any other nitrogenous fraction.

The work on this problem began in December 1953 and at the time of writing has not gone beyond the preliminary stages. The widely used and many times worked out and modified phenoldisulphonic acid method has been adopted for estimation, as more suitable for quantitative work than others. The method, however is a very delicate one and requires extreme care and speed to give reliable results. These two conditions are due to the use of fresh, finely cut plant material and the possible presence of soluble organic matter in the extracts. In these extracts, at temperatures exceeding 30°C., biochemical processes proceed vigorously and the losses of nitrate may be very considerable during the preparatory work, before the actual estimation. With all precuations taken, the recovery of nitrate added to plant extracts only rarely attained 100%. Usually figures fluctuated around 90%. This must be taken into account when actual nitrate content is estimated. For comparative purposes, however, the method is very suitable, being sensitive and good for routine work.

Generally nitrate-N content in cotton plant tissues is low in the later part of the season, an average being 5.53 mg.% in fresh plant tissue or approximately 0.028% in air-dry matter.

One observation is worth noting. Before the harvest began the guard rows in experimental plots were cut low. In February a new flush appeared, both on outer (cut) plants and on inner (uncut) ones. The examination of fresh tissues revealed a considerable difference in the concentration of nitrate-N : in the outer (cut) plants it was 7.5 mg.%, whereas in the inner (uncut) plants it was only 1.8 mg.%.

Volume Weight and Volume Composition of Gezira.

Soil at Gezira Research Farm.

Determinations of volume weight were carried out by sampling with a tube 4″ x 3″ in size having a volume of 600 ml. Sampling was performed vertically at 6-9″ (foot 1), 12-15″ (foot 2) and 24-27″ (foot 3). Results are as follows :—

Table 8.

Plot 94 angia 18

Averages for the months (Nov. 1953 — February 1954)
sampling twice per month
Immediately Before Irrigation.

Depth Feet	Density		Composition by Volume			% Moisture Oven-dry
	Field	Dry	Soil	Water	Air	
1 ...	1.57	1.20	45	37	18	31
2 ...	1.76	1.39	53	36	11	26
3 ...	1.74	1.43	54	31	15	22
Shortly After Irrigation.						
1 ...	1.62	1.18	45	44	11	37
2 ...	1.77	1.35	51	43	7	31
3 ...	1.72	1.37	51	36	13	26
Plot 16 Block 1, and Plot 17 Block 6 Unirrigated land. Average of 4 holes one East and one West in each Plot.						
Rainy months. Sept.-November.						
1 ...	1.65	1.25	47	40	13	31
2 ...	1.70	1.30	50	40	10	31
3 ...	1.65	1.30	50	35	15	26
Dry months (December to March).						
1 ...	1.50	1.19	45	31	24	26
2 ...	1.57	1.23	46	35	18	28
3 ...	1.65	1.31	50	34	16	26

The calculations of volume have been made as follows :—

$$\frac{\textit{Dry Volume Wt.} \times 100}{2.65} = \text{Volume of solid particles (soil).}$$

Field volume Wt. — Dry Volume Wt. = Volume of water

100 — (soil volume + water volume) = Volume of Air

Air space is higher on unirrigated than on irrigated land. It is higher before irrigation than after and also higher during the dry months on unirrigated land than during months with rains.

Cation Exchange.

The cation exchange capacity of clay soil has been reinvestigated using a new approach intended to avoid the difficulties caused by the solubility of calcium carbonate in displacing reagents.

The soil is shaken with a solution of potassium chloride and potassium carbonate. After standing, the supernatant solution is filtered off and treated with carbon dixoide-free potassium hydroxide and barium chloride. This is then titrated with N/20 HCl using phenolphthalein and bromophenol blue to give two end-points. The amount of carbonate reformed from bicarbonate is estimated from the difference between the sample and a blank titration to the phenolphthalein end-point. This is taken to represent exchangeable hydrogen. The difference between sample and blank titrations to the bromophenol blue end-point gives a figure which is equivalent to exchangeable Ca + Mg + H. From these two titrations the exchangeable Ca + Mg can be obtained.

The method gives the exchangeable H at pH 10 and the value for field soil (at a lower pH) is obtained from an experimental curve relating pH with exchangeable hydrogen.

The soil residue from the above determinations may be treated with dilute acetic acid to dissolve all the precipitated and original carbonates. This solution can then be used to give figures for ' total ' calcium and ' total ' magnesium. The calcium is precipitated in contact with the soil mass by addition of ammonium oxalate, which with the acetic acid buffers the solution at pH 4. The calcium figure is obtained by titration of the excess oxalate ion after filtration. Magnesium may then be determined as 8-hydroxy-quinoline on the filtrate after precipitation of sesquioxides with ammonia and ammonium chloride.

The following table gives some results obtained by this method with Gezira Soil.

Table 9.

Mechanical analysis and other data for Plot 304 : fine soil.

Depth	Sand %	Silt %	Clay %	pH	Salts mg. %
0–12″ ...	23	11	66	8.8	107
12–24″ ...	22	12	66	8.8	109

	Exch. H mg.e. %	Exch. Ca +Mg. mg.e.%	Total Ca mg.e.%	Total Mg mg.e.%	Organic C mg. %
0–12″ ...	8	38	102	10	234
12–24″ ...	8	36	106	10	226

Mechanical analysis and other data for Plot 36 : fine soil

Depth	Sand %	Silt %	Clay %	pH	Salt mg.%
0–12″ ...	26	12	62	8.9	78
12–24″ ...	23	13	64	9.0	126
24–36″ ...	23	12	65	9.1	139

	Exch.H mg.e.%	Exch.Ca + Mg. mg.e.%	Total Ca mg.e.%	Total Mg mg.e.%	Organic C mg. %
0–12″ ...	8	36	108	11	235
12–24″ ...	9	32	114	11	264
24–36″ ...	9	32	104	12	255

A comparison is given below between figures obtained by this titration method and those obtained by the following methods :—

1. Exchangeable calcium

10 g. soil is leached twice with 500 ml. 0.5N KCl. The figure obtained for calcium from the second leachate is subtracted from that obtained from the first to give the value for exchangeable calcium.

2. Total calcium

The soil residue from operation 1. is acidified with 15 ml. 5N acetic acid and leached a third time with 0.5N KCl. The sum of calcium determined upon the three leachates is taken as total calcium.

3. Total magnesium

10 g. soil is leached with 500 ml. 0.5N acetic acid. Magnesium is determined as the 8-hydroxyquinoline, after the elimination of iron and aluminium as hydroxides and of calcium as the oxalate. This value is taken, with reserve, as total magnesium.

Table 10.

Exchangeable and Total Calcium and Magnesium in certain Sudan Soils in m.e. %.

(a) by the titration method

(b) by the leaching methods

Soil Sample.	Ex. Ca		Total Ca		Total Mg.	
	(a)	(b)	(a)	(b)	(a)	(b)
G.R.F. Plot 36/1 ...	36	36	108	99	11	7
Wad el Nail W1/1 ...	41	37	72	64	19	13
Wad el Nail W12/1 ...	22	23	420	385	26	23
Um Sugura 10/1 ...	44	43	58	58	16	—
Um Sugura 15/1 ...	47	47	58	57	12	11
Um Sugura 18/1 ...	31	33	43	40	17	16
Ghadambalia B5/2 ...	40	39	75	68	14	12
Ghadambalia B10/1 ...	51	49	84	76	12	—
Gash 1/1 ...	16	21	35	31	7	4
Gash ... 2/1 ...	18	24	34	33	7	5
Tokar 3/1 ...	26	27	49	47	8	5
Tokar 5/1 ...	24	26	46	43	9	5
Tokar 6/1 ...	15	16	35	33	6	4
Nuba Mts. 271/1 ...	34	36	46	45	8	6
Nuba Mts. 274/1 ...	35	34	47	44	11	9
Nuba Mts. 279/1 ...	9	12	16	18	10	6
Wadi Gola 3/1 ...	32	32	55	53	8	5
Wadi Gola 8/1 ...	28	28	45	42	8	6
Wadi Gola 18/1 ...	7	9	15	14	6	3
Shendi 1/1 ...	23	24	40	37	9	6

N.B.—Figure (a) for exchangeable calcium may also contain a small amount of exchangeable magnesium.

Alkalinity of Gezira Soil at G.R.F.

Average G.R.F. soil in the first 2 feet has an exchange capacity of about 60 m.e.%; 15% of this is exchangeable Na. This is sufficient to classify it as an alkaline soil and to produce dispersion of the clay in water accompanied by development of high pH, 9.0 — 9.5 as measured in 1:5 soil/water suspensions.

The amount of alkalinity

This depends upon the method of determination as the figures below for the first 2 feet show :—

Method.	me%	pH
(a)	0.3	8.3
(b)	1.7	6.9
(c)	3.1	7.7
(d)	8.5	9.2

These alkalinities were determined by titration with N/20 HCl using bromophenol blue indicator with the following methods :—

(a) direct titration of 1 to 1 soil/water extract.

(b) titration of 1 to 20 extract after flocculation of the whole soil with N/20 KCl.

(c) as for (b) after flocculation of the suspended clay only, which is first removed by decantation.

(d) titration of the suspended clay conductimetrically with N/20 HCl without initial flocculation.

The pH of the 1 to 1 extract and also its titration capacity is much lower than routine pH measurements upon 1 to 5 extracts would suggest. In the field, moisture contents greater than 40% are uncommon and it may be assumed therefore that the pH does not exceed 8. Since, as has been shown, the amount of alkalinity is small it may be expected that in the proximity of the plant root this pH value will be further reduced, producing an environment not excessively alkaline. This may account for the absence of a number of deficiency symptoms normally associated with strongly alkaline conditions.

The nature of the alkalinity

In determinations (b) and (c) depression of pH is a normal salt effect. The increase in alkalinity with this depression is no doubt due to reaction between KCl and solid $CaCO_3$.

In determination (d) the shape of the titration curve does not resemble those for Na_2CO_3 or NaOH. The latter might be expected to result from hydrolysis of the sodium clay, as follows: Na_2-Clay + H_2O = NaH-Clay + NaOH. The general form of the curve is similar to that of the titration of the sodium salt of an acid of moderate strength such as tungstic acid. It has therefore been assumed that the titration is that of the sodium clay functioning as the salt of a strong base and a weak acid, rendered somewhat indefinite by the presence of Ca, both exchangeable and as $CaCO_3$.

The following table gives data for 1 to 20 soil/water suspensions prepared by shaking 10 g. soil with 200 ml. of distilled water intermittently for 3 hrs. and standing overnight. Such a procedure gives a suspension containing about 9% of clay which subsequently settles very slowly.

	me.%						
pH	Cl	SO4	Salts	Na(w)	Ca(w)	Na(Total)	Ca(Total)
9.2	0.1	0.3	3.9	5.0	0.4	4.8	3.3

Na (w) and Ca (w) are determined on the water suspension by the flame photometer. The Na (total) and Ca (total) are similarly determined after acid treatment.

Three points are of interest

(a) The sum of Cl + SO_4 + alkalinity = 0.1 + 0.3 + 1.7 = 2.1 me.% which is not sufficient to account for the salts determined electromerically.

(b) The sum of water-soluble Na and Ca determined in the flame photometer on clay suspensions is higher than electrometrically determined salts, which is reasonable if it is assumed that the clay micelle, which functions as the compensating anion has a low mobility.

(c) Water soluble Na = total Na (determined after treatment with dil. HCl).

Total Ca (after acid treatment) is considerably greater than water soluble Ca, since it includes $CaCO_3$. The sum (total Na + total Ca) approximately equals alkalinity determined conductimetrically, which is consistent with the explanation given above, namely that the alkalinity is mainly due to a sodium clay 'salt' plus carbonate.

Composition of the clay micelle

The figures given below compare the suspended clay with the whole soil. Results are given as me.% of the clay present in each case.

Clay	Ex. Ca	Ex. Na	Ex. H.
Suspended	10.0	51.6	26.8
Whole	50.2	15.2	13.4
$\frac{S}{W}$ ratio	0.2	3.4	2.0

These results imply that during dispersion Ca moves into the aggregated clay, and Na and to a lesser extent H, into the dispersed clay. It will be noted that the Na content of the suspended clay is very high indeed. Under field conditions this effect would be expected to take place, perhaps to a lesser extent, during puddling. This would help considerably to explain the dominating effect which Na has, compared to Ca which in the whole soil is present in far greater amount. It seems that the puddled clay soil may consist of relatively stable Ca clay-aggregates coated with sodium clay which, because it dominates the surface, donates its own properties very largely to the whole mass.

Examination of a Patch of Bad Cotton.

The 1952-53 annual report contained a reference to a small patch in Plot 213 with a long history of very poor cotton growth. It was shown that the stunted cotton was growing in a calcium soil while the surrounding cotton which was of good average size was in a normal Gezira sodium clay.

The relative permeability of the two soils determined on disturbed soil in the laboratory was as follows and is in accord with the chemical properties.

PLOT 213 PERMEABILITY OF DISTURBED SOIL.

Step	Ratio Bad/Good Soil.
0- 6″	1.1
19-24″	2.3

A detailed chemical examination of the two soils has now been carried out and the results are shown below. It is evident from table 11 that this is not a 'major' nutritional problem.

Table 11.

Analysis of bad (a) and good (b) soil in Plot 213.

p.p.m.

Step 6"	Nitrates		Organic N		Organic C		Truog P_2O_5 Available		Water Sol. K.	
	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
1 ...	1.0	1.2	340	290	3270	2920	350	270	34	30
2 ...	1.5	1.2	250	260	2750	2510	360	300	26	14
3 ...	0.8	1.5	250	260	2480	2590	320	290	—	—
4 ...	0.8	1.2	240	270	2380	2570	330	300	14	32
5 ...	0.9	1.2	250	240	2700	2700	330	320	24	28
6 ...	0.8	1.2	240	270	2750	2920	350	440	52	32
7 ...	0.9	1.0	210	230	2810	3130	290	390	50	26
8 ...	1.6	1.0	210	250	2270	3380	350	630	70	12
9 ...	1.0	1.0	260	290	2570	3460	—	—	72	—
10 ...	1.2	1.1	200	230	1940	2810	—	—	58	10
11 ...	0.8	1.1	190	170	1620	1970	—	—	52	50
12	1.2	1.6	170	170	1350	1570	—	—	54	60

From table 12 it is clear that low exchangeable Na in the ' bad ' soil has resulted in mobilization of Ca and Mg in the soil solution.

The figures shown are for 1 to 20 soil/water extracts.

Table 12.

Analysis of bad (a) and good soil (b) in Plot 213.

(Salts determined electrically ; water soluble Na and Ca in the flame photometer ; pH 1:20 suspension).

me.%

Step	pH		Salts		Water Sol. Na.		Water Sol. Ca.		Water Sol. Mg.	
	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
1 ...	7.9	8.3	2.9	2.2	0.6	0.9	1.6	1.4	0.3	0.3
2 ...	7.9	8.4	2.6	2.8	0.6	3.0	1.6	0.6	—	—
3 ...	7.9	8.9	2.6	3.3	0.6	4.3	1.4	0.2	0.1	0.1
4 ...	8.1	9.4	1.9	3.5	0.8	5.0	1.0	0.2	—	—
5 ...	7.9	9.4	4.6	3.4	0.6	5.0	3.4	0.2	0.8	0.1
6 ...	7.7	9.4	19.2	3.8	0.7	5.1	16.4	0.2	2.3	0.1
7 ...	7.7	9.4	21.2	3.8	0.7	5.4	17.1	0.2	3.3	0.1
8 ...	7.7	9.1	21.4	5.6	0.9	7.3	16.2	0.2	3.6	0.1
9 ...	7.7	8.3	22·4	13.7	1.3	12.5	17.4	6.9	3·9	0.9
10 ...	7.6	8.6	30.0	10.5	1.7	10.2	Greater	4.8	6.4	0.1
11 ...	7.6	8.0	26.6	28.3	2.2	14.7	than	13.8	—	3.0
12 ...	7.6	8.0	28.0	36.9	3.0	14.7	18.0	15.5	—	2.4

Recalculating the Mg figure for a soil solution at field capacity (about 40% water) gives the following result :

Table 13.

Concentration of soluble magnesium in bad (a) and good (b) soil at 40 % moisture.

Step	(a)	(b)
0– 6″	9	9
13–18″	3	3
25–30″	24	3
31–36″	70	3
37–42″	100	3
43–48″	110	3
49–54″	120	27
55–60″	190	3
61–66″	—	90
67–72″	—	70

In water culture experiments it has been confirmed, that concentrations of magnesium greater than 20 me. % produce very serious interference with the root system of both cotton and wheat. The top of the cotton tap root also develops a dark brown, rotten appearance. Calcium is known to produce an effect antagonistic to magnesium, and adding Ca in concentration equal to that of a saturated gypsum solution, which will be the amount encountered in these soils, largely prevents injury of the root system by magnesium in both wheat and cotton. A suspicion however still remains that the poor growth on the bad soil may be due to mangnesium toxicity.

YAMBIO EXPERIMENTAL FARM.

Agronomy Section.

By K. R. M. Anthony

INTRODUCTION

Rainfall for the year was slightly below average. This was mainly the result of a deficit in August, usually the peak month, and in September, when only 81 mm. fell compared with an average of 180 mm. for Yambio. To all intents the rains ended in the second week of November and were followed by a short but intense dry season. Meteorological data for the station are summarised in Table 2.

The pattern of distribution of rainfall, in terms of amount of daily precipitation, is shown in Table 1. Measurable precipitation occurred on 128 days as compared with 130 days last season, when total rainfall was 1721 mm.

Table 1.

mm. Daily rain ...	0.1–5.0	5.1–15.0	15.1–25.1	more than 25.1	Total
No. Days 1953 ...	63	32	20	13	128
Av. 1950-53	57	37	17	16	127
Total Rain 1953 ...	140.3	283.7	367.2	481.7	1272.9
Av. 1950 - 53... ...	127.1	352.3	344.2	626.4	1450.0
Percent of total 1953 ...	11.0	22.3	28.8	37.9	100.0
Av. 1950 - 53	8.8	24.3	23.8	43.1	100.0

The year proved a favourable one for crops and good yields of the three main crops were obtained. The sowing of groundnuts was slightly delayed because of a short dry period at the beginning of April but rainfall was well distributed throughout the growing season. The crop matured in 95-100 days after sowing and yields for first and second year land after fallow averaged 1200 r.p.f. unshelled nuts for the station. Main crop eleusine, following groundnuts, reached maturity in 115-120 days and averaged 1195 r.p.f. seed for the first and second years of the rotation.

The season was very satisfactory from the point of view of cotton. Good, well distributed rainfall favoured sowing, germination and early growth. Low September rainfall did not prove serious but some wilting at midday was observed on a few farm plots. Leaf reddening, attributed to deficient water supply, was recorded at this stage. The average yield for the district was 3.7 small kantars (100 rotls), giving a total yield of 63,980 small kantars from 17,520 feddans compared with 41,300 small kantars from 22,700 feddans in the disastrous 1952 53 season. Reduction in area sown was a result of withdrawal of cotton-growing from the red belt (the drier northern part of the region).

Because of little bad boll opening and compatively low stainer bug infestation, the quality of the crop was also enhanced. Grade I cotton averaged 67 per cent and Grade II 12 per cent of the total, compared with 29 per cent Grade I and 28 per cent Grade II last year.

At the Station, cotton yields were comparable with the 1952/53 season, when a bumper crop was obtained at the farm, in contrast with the district and as a result of better cultivation practice.

Long Term Experiments

Duration and Type of Fallows

In the first time replicate of rotation experiment Z, rotations B, D, K reverted to fallow and rotations A, C, E, H, L, were cropped with groundnuts followed by eleusine. Rotations, A, B, C, G, K, of the second time replicate were in the cotton phase.

Duration and type of fallow experiment Y was cropped with cotton and plots then reverted to fallow of various durations. This is a preliminary trial on types of fallow produced by various treatments during cropping and in the fallow period.

Catena Fertility Trial

Annual Crops

The longest duration of cultivation was in its fifth year of cropping Crop growth and yields, for the whole area, followed the downward trend indicated last season. Groundnuts averaged 185 r.p.f. and eleusine 257 r.p.f. representing only 15 per cent and 22 per cent respectively, of the farm average for the season for the first two years of cultivation after fallow.

Germination, growth and yield of sesame were all poor, the crop averaging 55 r.p.f. seed for the trial.

Cotton was the seventh crop in five years. It was sown on June 15 and a good stand obtained. From the beginning the crop looked miserable, with poor vegetative growth, the final height averaging only 52 cm. Nevertheless, it bore approximately four bolls per plant and the final yield averaged 448 r.p.f. This was higher than the average yield for the district and 45 per cent of that of the adjacent BAR. 11 5 bulking area on first and second year land.

Fallows

On plots after five years of cultivation, *Imperata* had lost its dominance to *Bidens* and *Eragrostis* spp. in the dry season. Soil coverage was low. On land which had been under fallow for a year, following four years cropping, a thick stand of *Imperata* dominated the whole area. The greater part of the recolonising bush growth was coppice.

With three years fallow, after two years cultivation, *Imperata* was almost completely suppressed in many plots. Bush regeneration has followed the same general pattern as on the uncultivated plots. That is, suppression of *Imperata* and the tall grasses by *Vernonia* spp., *Ficus* spp. and the scandent shrubs with emergents coming away from coppice growth.

Continuous Cultivations Plot

This trial represents a cropping-to-exhaustion plot in the third year of cultivation. Layout is described in the 1952/53 Annual Report.

Yields of both groundnuts and eleusine were poor. Groundnuts averaged 679 r.p.f. and eleusine 685 r.p f. compared with 1679 r.p.f. and 1164 r.p.f. respectively from second year land on the adjacent Continuous Cultivation Methods Experiment. The eleusine plot contained a considerable quantity of Eragrostis, a characteristic weed of overcultivation.

Cotton was vegetatively poor but yielded 560 r.p.f. comparable with control plots on the adjacent strip.

Continuous cultivation methods

Object, treatments and layout are described in last season's report. The experiment is in its second year. Cotton variety BAR. SP84, sown June 9.

Treatments are applied in the cotton phase of the rotation, the groundnuts — eleusine phase this year measuring residuals of treatments applied to the 1952;53 cotton crop. No significant difference was recorded between the respective residual treatments. But in the case of the eleusine crop a considerable degree of variability was introduced as a result of uneven broadcasting.

Responses to treatments in the cotton phase are summarised in Table 3.

Table 3.

	r.p.f. Seed cotton	
	1952/3	1953/4
Control	471	591
Grass mulched	538	797
Tiled mulched	338	524
Ridged	411	714
Cross tied	458	623
Ridged + F.Y.M.	613	749
Cross tied + F.Y.M.	685	745
Ridged + N.P.K.	547	892
Cross tied + N.P.K.	579	775
Significant Difference P = 0.05	81	146
Significant Difference P = 0.01	110	198
Coefficient of Variability	10.9	14.2 per cent.

In the previous season yields of groundnuts and eleusine on these plots showed only slight variation between treatments.

A light grass mulch produced the quite remarkable response of 35 per cent increase over control. Height records showed that plants in this treatment made better growth than in control plots during late July-August. However, no significant response was obtained with cross tieing. Tile mulching again produced depressed yields and poor vegetative growth though the decrease in yield did not reach the level of significance.

With ridging and cross tieing, farm yard manure at 10,000 kg. per hectare, applied at the time of ridging, produced a 26 per cent response compared with control slightly below that of last season.

The standard N.P.K. dressing as nitrate of ammonia at 200 kg. per hectare, superphosphate at 400 and sulphate of potash at 200 kg, per hectare was applied prior to sowing. Responses were greater than last year, 51 per cent with ridging and 31 per cent with cross tieing.

Factors Influencing Crop Production.

With the new soils laboratory still under construction the approach to these problems had to be mainly agronomic.

Time of opening land for cultivation

The length of interval between opening land for cultivation and sowing the crop appears to be an important factor in crop production. Early clearing and burning of the bush, within limits, may be beneficial by resulting in increased moisture content of the soil, stimulation of nitrate accumulation and other factors still unknown. Stimulation of nitrate accumulation is probably encouraged by the effect of increased soil temperature, moisture conservation and possibly insolation.

The object of this experiment was to determine the effect of early opening on crop production, cotton being used as an indicator crop. Further work would depend on the nature of the responses obtained.

Two openings, early and late, were replicated six times in this trial. As the edge effect of tree roots from the later openings could be expected to influence seriously the early openings, plots were separated by cleared belts, five metres wide. Plots were split for four combinations of two sowing dates of cotton and two weeding treatments of the crop. Plots 400 sq.m. harvested ; sub-plots 100 sq.m. harvested. Cotton, variety BAR. 11/5.

The early opened treatment and belts were cleared and burnt at the end of March, which usually marks the beginning of the rains. This treatment was kept clean weeded until sowing. Late opened plots were cleared in mid-May for June-sown cotton and mid-June for July-sown. Cotton sowing dates were June 2 and July 2 respectively. Weeding treatments compared station practice and clean weeding of the crop (see Cotton Associations Experiment). With June-sown cotton, four weedings prior to cropping, plus a fifth at 152 days after sowing, were sufficient to achieve clean weeding. The fifth weeding proved unnecessary in the case of July-sown cotton since the crop was picked in the dry season when weed growth was negligible.

There were no visual differences between treatments. Yield data, as rotls per feddan seed cotton, are summarised in Table 4.

Table 4.

Sowing Date	Weeding	Opening		
		Early	Late	Mean
2.6.53	Station	1124	1013	1068
	Clean	1202	1107	1154
	Means	1163	1060	1111
2.7.53	Station	540	592	566
	Clean	556	579	567
	Means	548	585	566
	General Means ...	855	822	838

Significant Difference, sowing dates, (P= 0.01) = 78 r.p.f.
Significant Difference, openings x sowing dates, (P= 0.05) = 81 r.p.f.
Coefficient of Variability = 11.5 per cent.

With June-sown cotton the early opening treatment outyielded the late opening by 10 per cent. No significant response was obtained in either direction with the July sowing. As results were available from only one experiment and the response obtained was indefinite, no conclusions can be drawn. Further field experiments, with more drastic treatments and supported by laboratory data, are envisaged.

The July sowing yielded only 75 per cent of the June. This was in conformity with usual experience. Counts of stainer bugs *Helopeltis* and pink bollworm throughout the season showed no marked differences between the two sowing dates.

As in the Cotton Association Experiment, station standard weeding practice proved near enough to the optimum. From the point of view of organisation of the programme of work it is desirable to conform, as far as possible, to definite dates of operations. Weedings at 20, 40, 70 and 130 days after sowing achieve adequately clean crop conditions. Weedings after the commencement of picking is unnecessary. Even last season, when heavy late rains resulted in very intense weed growth during the picking period, this appeared to hold true.

Fertiliser trials.

These trials form part of a programme of field experiments, planned in collaboration with the Soils Section, to provide data on the responses to be obtained from the application of the main plant nutrients to our soil types. It is not envisaged that application of artificial fertilisers will be economic in this area in the foreseeable future. Their use, experimentally, is an essential part of the attempt to assess the limiting factors in soil fertility, through correlation between laboratory results and crop response data.

In 1953/54 a preliminary N.P.K. trial, with and without planting on ridges, was carried out with cotton as indicator crop.

Sixteen combinations in six blocks of eight plots, the highest order interaction confounded. Plot size 100 sq.m. harvested. Cotton, variety BAR. 11/5. sown June 19 Sulphate of ammonia at the rate of 400 kg/ha and sulphate of potash at 200 kg/ha applied just before flowering; superphosphate at 400 kg/ha by placement.

No response was obtained to the application of potash or to any of the interactions. Significant main responses are summarised in Table 5.

Table 5.

	ON	N	OP	P	No Ridging	Ridging
Rotls per feddan seed cotton	594	673	555	711	606	661

Significant Difference, (P = 0.05) = 41 r.p.f.
Significant Difference, (P = 0.01) = 54 r.p.f.
Coefficient of Variability = 11 per cent.

The phosphate effect was masked by faulty sowing of the non-phosphate plots and the response was, at least in part, due to difference in stand and must be treated with reserve pending further results. The response to nitrogen was low, a 13 per cent increase over no nitrogen being obtained for a heavy dressing of sulphate of ammonia. Ridging produced a 9 per cent increase, which clearly did not justify the labour involved in the operation.

An experiment, cropped in 1953/54, investigated the effect on the subsequent crop of groundnuts or cotton of N.P.K. applied to the bush at the beginning of the previous rains. Superphosphate was at the rate of 400 kg/ha and nitrate of ammonia and sulphate of potash at 200 kg/ha. No significant responses were obtained.

A field trial with cotton was also carried out on some possible locally available fertiliser amendments. Cotton seed meal was applied at the rate 1,000 Kg/ha, termitaria earth and munga earth at 10,000 kg/ha. (A munga is a pan formation, with impeded drainage, which receives runoff from the surrounding land). Four treatments were replicated six times, with plot size 100 sq.m. harvested. No response reached the level of significant at P = 0.05.

Mulching

An experiment was laid down on Road D comparing the effect of grass mulching of cotton with and without nitrogen. Nitrogen was applied 60 days after sowing in the form of sulphate of ammonia at 400 kg/ha. Four treatments were randomised in six blocks on first year land. Plot size 100 sq.m. harvested.

Responses of 8 per cent mulching and 9 per cent for nitrogen did not reach significance. The treatment without mulching or nitrogen averaged 943 r.p.f. seed cotton. The response to mulching contrasts with that on the Continuous Cultivations Methods Experiment on second year and poorer land on Road A, where a light grass mulch was used.

Cotton

Cotton variety trial

Four varieties in six randomised blocks. Plot size, 100 sq.m. harvested. Cotton sown June 17. Yield data and results of Shirley Institute spinning tests are given in Table 6 and 7 respectively.

Table 6.

Variety	r.p.f.		G.O.T.
	Seed Cotton	Lint	
BAR. SP. 84	712	248	34.8
BAR. 11/5	661	227	34.4
BAR 7/8.1	836	317	37.9
S 47	665	225	33.9

Significant Difference, (P = 0.01) = 46 r.p.f. lint

Coefficient of Variability = 11.0 per cent.

Table 7.

Variety	Eff. Length 32's.	Maturity Ratio	Standard Fibre Wght.	C X S 40's	Yarn Appearance
BAR. SP. 84 ...	38	0.825	194	2018	5
BAR. 11/5 ...	36	0.810	188	2084	4
BAR. 7/8.1 ...	37	0.880	181	1909	6
S 47	39	0.875	173	1855	7

BAR. 7 8.1 outyielded BAR. SP 84 by 28 per cent and BAR. 11 5 and S 47 by 40 per cent of lint. In view of the high yielding capacity of BAR. 7/8.1, confirmed by Cotton Breeding Section trials elsewhere, the Chief Cotton Breeder advised holding BAR. 11 5 at the present 70 feddans level of bulking during the next season, pending further variety trials and spinning tests on BAR. 7/8.1 and 7/8.2.

A 4.3 feddans bulking area of BAR. 11/5 on first and second year land on the farm averaged 980 r.p.f. of seed cotton.

Cotton Seed Treatment.

Blackarm disease of cotton (*Xanthomonas malvacearum* Sm.) is never serious in cotton areas of the south western Sudan. Varieties under cultivation have a high degree of resistance to the disease but, at the same time, serious blackarm has not been observed on comparatively non-resistant varieties grown in this area. However, in view of the extremely good response obtained in Uganda to cotton seed treatment with Perenox it was considered desirable to assess the value of seed treatments under local conditions.

A small field trial was carried out with cotton. Three treatments were included:—no seed dressing, cotton seed treated with Perenox, cotton seed treated with Abavit B. Seed dressings at rate 1 : 150 by weight. Six replications in a randomised block experiment. Plot size 100 sq.m. harvested. Cotton variety BAR. 11,5, sown June 26.

A count of the number of blackarm-infected seedlings was made before thinning. For the whole experiment, 23 were recorded out of a total population of 20,000 seedlings. These seedlings exhibited characteristic waterlogged spots on the cotyledons which soon dried out and infection was not disseminated. This is the only stage of the disease normally experienced in this area.

No positive yield responses were observed as a result of the dressings applied. Untreated cotton yielded 757 r.p.f., treated with Perenox 741 r.p.f.; treated with Abavit B 717 r.p.f.

Cotton Associations.

This was a continuation of cotton association trials carried out at the Station during the last two seasons. The most successful and practical association appears to be that where cotton is sown into a leguminous crop planted at the beginning of the rains.

Early Associations Experiment.

This season the farm trial compared cotton sown alone to cotton sown into an early crop of *Phaseolus angularis*. Three weeding treatments were also superimposed to assess yield differences attributable to standard farm practice, clean weeding and average cultivator's practice. It was particularly desired to assess the effect of poor weeding at the time of bud formation, a common feature of cultivations in the district. As cotton sown into an early associate is usually much cleaner in appearance than when no early crop has been sown, it was anticipated that the effect of weeding treatments would be less pronounced in association with *Phaseolus*.

Six combinations of two associate and three weeding treatments, replicated five times. Plot size, 100 sq.m. harvested. *Phaseolus angularis* sown April 20, at a spacing of 30 x 30 cm. and harvested July 6—21. Cotton, variety BAR. 11,5, sown June 2 at a spacing of 90 x 30 cm. thinned to 2 plants per hole.

The standard station weeding was at 20, 40, 70 and 130 days after sowing. With clean weeding, the crop again received four weedings prior to picking, but at a slightly different timing, plus a fifth at 157 days. To imitate an average cultivator's practice the weeding at 40 days, covering the bud formation period, was omitted.

The land was opened in the latter half of March but lack of rain delayed sowing of *Phaseolus*, which went in rather late for minimum interference with cotton growth. It received one resowing. *Phaseolus* stores well and germination is generally good, as was the case in this experiment, when an initial stand of 85 per cent was obtained. This is adequate and resowing appears to be a practice not to be recommended as it prolongs the period during which the crop is in association with cotton. This results in reduction of cotton yield, which is not in proportion to any insignificant increase in yield of beans. Where beans were not sown the land was kept clean weeded until cotton sowing.

The stand of cotton was not seriously affected by being planted into *Phaseolus* and only 9 per cent of blanks occurred compared with 3 per cent without associate.

In conformity with previous years' experience, cotton growth was depressed by the associate and, although growth rate increased after harvest and hoeing of the *Phaseolus*, final height of the crop averaged only 83 cm. compared with 112 cm. for treatments without the associate. In addition, the vegetative period was lengthened by some ten days. Mean budding for cotton in association was 73 days and mean maturation 164 days after sowing, compared with 62 and 154 days for control. Yield data, as rotls per feddan seed cotton, are summarised in Table 8.

Table 8.

	Weeding Treatments			
	Clean	Standard	Cultivator's	Mean
Cotton alone	1,359	1,225	1,208	1,264
+ Phaseolus	838	796	636	757
Mean	1,098	1,010	922	1,010

Significant Difference, associates, (P=0.01) = 125 r.p.f.
Significant Difference, weedings, (P=0.02) = 109 r.p.f.
Coefficient of Variability = 11.8 per cent.

Cotton in association yielded only 60 per cent of cotton alone but, in addition, a crop of 870 r.p.f. beans was obtained.

This, and previous trials, demonstrate the importance of sowing the leguminous crop as early as possible in order to reduce the period of competition with the cotton to a minimum. Resowing of the early crop should be avoided as it extends the growing period and reduces the return on cotton out of all proportion to the return on the legume.

Weeding treatments show that present station practice is close to optimum. Omitting the weeding at 40 days after sowing did not produce quite so large an adverse effect as was expected, although admittedly this is dependent on season and the efficiency of the first weeding. The more pronounced effect of the omission in the *Phaseolus* plots was apparently due to dehiscence of the pods, with consequent reseeding and additional competition.

Extension Trial.

An extension trial was undertaken on our behalf, by the Equatoria Projects Board field staff, on cultivator's holdings near Yambio. Plots were in two lines in a single settlement unit. The object was to assess the practical difficulties of putting this type of association into practice under the present local agricultural system.

As originally planned, ten cotton plots each were to be sown with *Phaseolus angularis* or soya beans with an equal number of control plots. In practice, only eight plots of soya beans and nine plots of Phaseolus were planted. It was not found possible to standarise the size of plots.

The bulk of the legume crop was sown by the middle of May, which is considered late for best results. Cotton was sown in mid-June. Cotton in association suffered from delayed growth and was again later than cotton alone. Yield data are summarised in Table 9.

Table 9.

	Soya Beans + Cotton	Phaseolus — Cotton	Cotton alone		
			Soya Control	Phaseolus Control	All Plots.
No. of cultivators ...	8	9	8	9	17
Total area feddans ...	4.89	5.41	5.29	4.91	10.20
Cotton yield r.p.f. ...	624	471	438	473	455+
Beans yield r.p.f. ...	477	508	—	—	—

The comparative yield data must be treated with great reserve in view of the unsatisfactory nature of the trial statistically. However, it demonstrated that this type of association can be carried out satisfactorily at the cultivator's present level. Both soya beans and *Phaseolus angularis* would be a most valuable protein supplement to the present Zande diet, once the initial suspicion of the cultivator towards new food crops is overcome. Grown in association with cotton considerable labour saving is undoubtedly achieved in their cultivation.

Cotton with late associates experiment.

This represents the second year of an experiment started in 1952 and described in last season's report. Survival rate of the chillies and ratooning dura throughout the dry season was low and negligible crops obtained.

Fibre Crops.

Seven observation plots, each, of kenaf, Roselle hemp, jute and *Urena lobata* were established on first year land. The fibre were sown on July 30 after a crop of groundnuts.

The season was not suitable for such late planting and the growing period was shortened considerably. Jute averaged only 75 cm. height and yielded 96 r.p.f. fibre. Kenaf and Roselle hemp averaged 266 and 145 r.p.f. fibre with final heights of 110 and 85 cm. respectively. *Urena lobata*, with its long growing period, was not harvested until January 6, nearly two months within the dry season. Despite this, it averaged 135 cm. height, yielding 417 r.p.f. fibre, which was 6.3 per cent of the green stem weight.

In all cases, owing to the comparative severity of the dry season difficulty was found in obtaining a sufficient quantity of clean running water for the retting ponds. Everything indicates the desirability of planting fibres as early as possible in the rains both from the point of view of optimum yield and retting.

Introductions of varieties of Ramie (*Boehmeria bivea*) were made from Malaya and Uganda. These are being propagated to provide material for observation plots.

Tree Crops.

Establishment of coffee trees in the road D area in 1949, on the previous system, was far from good and the bulk of the stand is 1950 planted. The results showed that only 96 trees of the 1949 plantings survived. These gave 255 rotls dried cherry or nearly 1.5 rotls clean coffee per tree. The 1950 plantings averaged 0.5 rotls clean coffee tree. Plantations will be extended next season.

The bulk of the tung on Road D was planted in 1949. Under ocal conditions trees appear to bear throughout the year, with a dry season and a wet season peak. The annual period from September 30 to September 29 appears suitable for computing comparative yields In 1951 2 and 1952 3 yields were negligible but in 1953 4 the whole plantation came into bearing. Three have made good growth and tung oil offers every promise as a cash crop for this area.

The present plantation of tung was established from seed obtained from a commercial plantation in the Belgian Congo. Further material will be introduced from other sources as a basis for comparison, selection and breeding work. More observation plots at the Station and in the district are planned for next season and trials will include the possibilities of coffee and tung oil in association.

An eight feddans plantation of H x H oil palms from Nigeria, has been established on the corridor system. It is planned that this will form the nucleus of a future seed farm for production of Durum, H x P and H x T seed.

During the dry season, nursery beds of Cashew nut and Pachira nut were established for planting observation plots in 1954.

Routine plant propagation and distribution continued.

Strips on Road D were allocated to propagation of BAR. 11/5 cotton under isolation and seed was issued to the Equatoria Projects Board for sowing three village lines, amounting to an area of some 70 feddans.

Amongst food crops emphasis was laid on protein-rich crops, particularly soya beans and *Phaseolus angularis*. Quantities of seed were distributed to the Equatoria and Bahr el Ghazal. At the Station, yields of soya beans, on propagation plots of 1/9 feddan each, ranged between 500 and 1000 r.p.f. The most suitable varieties take 80-90 days from sowing to harvest. These can be sown either at the beginning of the rains for harvest in July after cotton sowing, or as a June-July sown crop for harvest in the comparatively slack period of September-October, prior to cotton picking and the eleusine harvest. *Phaseolus angularis* can be fitted into the same period, yields around 1000 r.p.f. beans and in addition is a useful cover crop for plantations. Both are suitable for growing in association with cotton. In all cases, attention was paid to palatability and cooking qualities. Extension work, as usual, will have to combat the Azande's conservative attitude towards new introductions.

The small plantation of Gros Michel bananas was in bearing and has been extended. The variety proved superior to local varieties both in production and quality.

YAMBIO EXPERIMENTAL FARM.

by E. M. McDermid.

NOTE :— The results of the work at Yambio from 1952 to 1955 will have been published elsewhere. Much detail has therefore been omitted from this report.

Review of Insects on Cotton Throughout The Season.

DYSDERCUS spp. The infestation remained at a low level throughout the season. The annual invasion of the crop began during September and stainers were present until hygiene measures were imposed. A dry period for the last ten days of September adversely affected incubation of eggs. Eggs which hatched took an average of fourteen days as against a normal average period of seven days. (Laboratory breeding figures). Even with regular daily watering the relative humidity during this period was sufficiently low to prevent hatching (57—58% as against 62—66% in 1952). Hatching occurred only when the relative humidity rose above 62% (64 for pentad October 3-7). This low moisture must have been responsible for a high mortality of eggs in the field. This period is a crucial one for build up of *Dysdercus* population in the crop because it represents a time when primary breeding in the crop is taking place. It is therefore probable that the low seasonal level of population was a direct result of the September drought.

Dysdercus superstitiosus F. (Hemiptera : Pyrrhocoridae) was by far the most abundant species. *D. nigrofasciatus* Stal.—and *D. melanoderes* Karsch were proportionally common in collections made during September and October. *D. melanoderes* is normally rare. It is probable that the abnormally wet 1952-53 "dry" season encouraged a high dry season carry over and enabled the large population increase to take place. Specimens of *D. haemorrhoidalis* Sign. and *D. cardinalis* Gerst. were captured on the crop in early October and a probable cross between *D. nigrofasicatus* and *D. melanoderes* (*D. nigrescens* ?) was also taken at that period.

At the end of November adult *Dysdercus* began to move to *Sterculia tomentosa* Guill. and Perr. (Sterculiaceae) and the population on cotton remained predominantly nymphal until the plants were destroyed.

Helopeltis schoutedeni Reuter. (Hemiptera : Capsidae). Specimens were found on the crop from the cotyledon stage (late June) until the bolls began to ripen and open (late October). The periods of peak population were mid-August, when feeding was centred on the rapid flush of young green leaves, and late September when feeding was concentrated on the enlarging green bolls. During November it became very difficult to find the insect. Infestation was only heavy locally and was generally unimportant. Specimens of *H. proxrubrinervis* Poppius were also collected on cotton.

Platyedra gossypiella, Saunders. (Lepidoptera : Gelechiidae). The crop was infested with pink bollworm larvae from August until hygiene measures were enforced. The larvae attacked both buds and bolls. The percentage infestation revealed by examination of bolls picked from the plant was much higher than that of shed collections. The attacked was heavy. The average infestation in the crop near Yambio for the season, calculated from collections of fruiting points from the plants, was 47. Assuming that only one locule of a boll was damaged, the crop loss for such infestation is roughly 12% which for the total E.P.B. area crop is approximately 10,000 small kantars of seed cotton.

P. gossypiella, was also found in ripe fruit of Halics *esculentus L.* (Malvaceae), *H. cannabinus* L. (Kenaf), and *H. sabdariffa* L.

Other insects Grasshoppers (*Catantops* spp., *Oedalus* spp. and *Gynnobothrus* spp. Orthoptera : Acrididae) and aphids attacked cotyledon cotton and caused slight damage.

Grasshoppers (probably *Zonocerus variegetus* L. Orthoptera : Acrididae) attacked seedling cotton and in localised patches defoliated it.

Leaf rolling caterpillars (*Sylepta* spp. probably *derogata* F. Lepidoptera : Pyralidae), Jassids (*Empoasca* spp. Hemiptera : Jassidae) and various species of capsids were also collected from the crop. In general, their incidence was rare.

Experiment to Grow Cotton free from Pests

Layout.

Two plots, each of 12.5 x 12.5m., were laid out with a belt of 2.5 m. on all sides. They were sown on June 17 with BAR. 11/5 cotton spaced 90 x 30 cm.

Methods

Five cotton plant diagrams were made in each plot. Each plot was compared with a similar nearby untreated plot. Bud and Boll sheds were collected from all cotton diagram plants. Yield data were recorded. The ratio of seed to lint was determined and seed viability tests undertaken.

Treatment.

The two plots were treated every ten days with an 0.1% insecticidal mixture of B.H.C. and D.D.T.* applied at the rate of 150 gallons per feddan. Treatment was suspended for twenty days between late August and mid-September to allow free pollination during the period of peak flowering. Fourteen applications of insecticide were made as follows :—July 18, 28, August 8, 18, 29, September 19, 29, October 10, 20, 31, November 10, 21, December 1 and 12.

Footnote.* Throughout this report insecticidal mixture of BHC and DDT means agrocide dispersible powder (6.5% gamma benzene hexachloride) and 50% DDT dispersible powder.

Results

The yield data for the protected plots and their comparison plots are given in table 1.

Table 1.

Yields of cotton plots protected from pests, and their comparison plots.

Plot	Yield rotls feddan			% of total		
	A	B	C	A	B	C
Protected Plot. A.	286	148	71	56.6	29.3	14.1
Comparison plot A.	333	119	47	58.4	29.8	11.8
Protected plot B.	386	148	98	61.1	23.4	15.5
Comparison plot B.	368	369	280	36.2	36.3	27.5
Average protected plots ...	336	148	85	59.1	26.0	14.9
Average Comparison plots ...	301	244	164	42.5	34.4	23.1

Plot.	Grades A + B (Saleable).		
	Total	% of comparison	
		1953	1952
Protected plot A.	434	124	157
Comparison plot A.	352	100	100
Protected plot B.	534	73	125
Comparison plot B.	737	100	100
Average protected plots	484	89	139
Average comparison plots	545	100	100

Results of examination of bolls harvested are tabulated in table 2

Table 2.

Details of bolls harvested from plots protected from pests and their comparison plots.

Experiment.	% Sound Bolls	Division of Damage %	
		Pink Boll-worm.	Other Damage.
Protected plot A.	63.6	13.7	13.7
Comparison plot A.	42.8	42.8	14.4
Protected plot B.	42.1	15.8	42.1
Comparison plot B.	43.7	25.0	31.3
Average protected plots	53.7	14.7	26.8
Average Comparison plots	43.4	33.3	23.3

	Grade A.		Grade B.		Grade C.	
	Seed/ Lint	Aver./ Seed Wt. g	Seed/ Lint	Aver./ Seed Wt. g	Seed/ Lint	Aver./ Seed Wt. g
Protected plot A.	2.15	.09	1.86	.07	2.3	.09
Comparison	1.91	.08	2.25	.05	4.9	.08
Protected plot B.	2.21	.08	1.70	.07	2.5	.06
Comparison plot B.	1.87	.09	1.68	.07	—	—
Average protected plots ...	2.17	.08	1.77	.07	2.41	.07
Average comparison plots ...	1.90	.08	1.74	.06	4.0	.08

Comments.

Comparison between the protected plots and the other plots are probably invalidated by the considerable difference in times of sowings particularly between plots B. Both protected plots yielded less. heavily than their counterparts in 1952 due probably to a later sowing date Grading of the harvest was also poorer than in the previous year. As last year, increase of P. *gossypiella* was greater in bolls harvested from the comparison plots than from the protected ones. There was little difference in the viability of the seed. The development of the plants was not markedly different in the sprayed and control plots nor was the pattern of shedding, most of which was from unknown causes. In general, there is no indication of any benefit from spraying in these observation plots.

Caging experiment to assess damage caused to the cotton crop at yambio by Dysdercus spp. and Helopeltis Schoutedeni Reut.

Layout.

A plot 100 x 35 m., divided into three sub-plots, under cotton for the second year, was opened, sown and maintained according to normal standard Y.E.F. practice. BAR. 11/5 cotton at a spacing of 90 x 30 cm. was sown on June 22.

Thirty two plants were selected for the experiment, sixteen in sub-plot 1 (*H. Schoutedeni*), four in sub-plot 2 (control) and twelve in sub-plot 3 (*Dysdercus* spp.). All these plants except the four of sub-plot 2 were caged in wire cages at some time during the experiment. Details of the caging procedure are summarised as follows :—

Helopeltis schoutedeni. Plants 1-4 ; caged July 7—August 4 (28 days) ; population adult male and female ; cage 3 not populated—control.

Plants 5—8 ; caged July 7—August 4 (28 days) ; population adult male and female ; cage 7 not populated—control.

Plants 9-12 ; caged September 3—October 1 (28 days) ; population adult male and female ; cage 11 not populated — control.

Plants 13-16 caged October 7—November 4, (28 days) : population adult male and female ; cage 15 not populated — control.

Dysdercus superstitiosus. Plants 21—23 ; caged all season ; populated October 13—November 12 and November 16-23 (37 days) with adult male and female.

Plants 27—29 and 31 ; caged all season ; populated November 23—December 14 (21 days) with adult male and female and 2 nymphs.

Dysdercus nigrofasciatus. Plant 25 caged all season ; populated October 13/November 12 and November 16—23 (37 days) with adult male and female.

Plant 32 caged all season ; populated November 23—December 14 (21 days) with adults male and female and 2 nymphs.

Dysdercus melanoderes. Plant 26 caged all season ; populated October 13—November 12 and November 16—23 (37 days) with adult male and female.

Plants 24 and 30. Caged all season ; not populated — controls.

Plants 17—20. Not caged — controls.

(**N.B.** It was intended that the November—December population of *Dysdercus* spp. should be caged for 30 days but after 21 days all bolls had been harvested and the experiment ended prematurely).

Treatment.

All experimental plant holes were thinned to one plant per hole and thoroughly weeded on July 7. Then all plants except the four July *H. schoutedeni* plants were sprayed with a 0.1% insecticidal mixture of B.H.C. and D.D.T. at the rate of 100 galloms per feddan on July 22. The ten *Dysdercus* spp. and the two caged control plants were caged immediately after spraying. Thereafter all *H. schoutedeni* plants were sprayed every seven days at the same rate and at the same strength of insecticidal mixture with the exception of the 14 days prior to caging, and the 28 days of caging.

Method.

Populations of *H. schoutedeni* and *Dysdercus* spp. were maintained at correct levels by daily examinations and replacements.

Cotton plant diagrams were made on all 32 plants. All bolls on all plants were harvested and examined. Yield data were recorded. The seed to lint ratio of each boll was determined and tests of seed viability made.

Observations.

Plants caged in July and August were seriously attacked. Plants 2 and 4 (July) and plants 5, 6 and 8 (August) were killed. The other was killed at the apex and development was greatly retarded. In September cagings *H. schoutedeni* fed on the green bolls, causing much premature splitting along carpel sutures and some secondary internal rot. Feeding on October-caged plants was on bolls and on fresh apical leaf growth. At this stage of development the leaf feeding was unimportant and the riper bolls were not seriously affected.

Dysdercus species did not maintain themselves readily for the earlier period of the October—November infestation and fresh insects frequently had to be introduced. Feeding punctures did not produce much staining of lint. In order to relate it better to the population level in the fields, the November—December infestation included nymphs. It was longer lived and bred in the cages. Staining of the lint was more common.

Discussion.

According to Congo observations, attack by *H. schoutedeni* is heavy when there are 50 insects per 1,000 plants and serious when there are 100 or more insects per 1,000 plants.* The infestation of 2,000 insects per 1,000 plants maintained in the experiment would therefore be expected to annihilate the crop. Young plants were killed or maimed and the yield of older plants reduced by a half.

The cotton plant diagrams show that more bolls were borne by the caged control plants than those populated by *Dysdercus* spp. and that a greater proportion of those borne were grade A. The proportion of grade A bolls borne by the *Dysdercus* plants was slightly greater than that borne by the uncaged control plants. A similar number of bolls was borne by the *Helopeltis* plants and by their controls but for the most part of bolls of the former were of lower grades. The uncaged and *Helopeltis* controls were similar both in number and grading of bolls borne.

Contrary to the impression produced by visual observation, examination of bolls showed that staining of the lint was greater for the October-November *Dysdercus* infestation and for *D. nigrofaciatus* and particularly *D. melanderes* populations. The proportion of bolls damaged on *Dysdercus* plants was about 20% greater than on caged control plants and was mostly attributable to staining of the lint. A similar proportion of bolls was damaged on *Dysdercus* plants and on uncaged control plants where *Platyedra gossypiella* larvae were the most important destructive agents. A proportion of about 35% of bolls damaged on *Helopeltis* plants over that of *Helopeltis* control plants can, almost all, be directly attributed to damage of *H. schoutedeni* for each month.

Both *Dysdercus* and *Helopeltis* plants produced a lower percentage of viable seed than the controls, which all produced a similar percentage.

Footnote * G. Schmitz. (Bambesa) "Comment limiter les degats de L' Helopeltis due cotonnier dans L'Ubangi-Uele ?" Bulletin d' Information de L'Ineac, September, 1952.

The yield for *Dysdercus* plants was lower than that of the caged control plants by an average of 30% of saleable seed cotton. Except for *D. nigrofasciatus* in October, and *D. melanoderes*, it was higher than the uncaged controls due to protection from bollworm attack.

Conclusions.

Conditions peculiarly favourable to build-up of population of the pest *H. schoutedeni* can cause serious damage to the crop, killing young plants, lowering the amount and grade of the yield and affecting viability of the seed. The pest was normally present in numbers insufficient to be regarded as more than a pest of minor importance. *Dysdercus* species are confirmed as major pests causing lowered yields and lowered viability of the seed.

Experiment on Treatment of Soil with Insecticide against Dysdercus Species.

Layout.

The eight cotton isolation plots were utilized for the experiment. Each plot was 20 x 10 m. and was sown June 15 with cotton spaced 90 x 30 cm. and maintained according to normal standard Y.E.F. practice. Details of the layout are given in table 3.

Table 3.

Layout of soil insecticide trial against *Dysdercus* spp.

Plot No.	Cotton variety	Treatment.
1	BAR. 12/3	None-control.
3	Stoneville	None-control.
4	S. 47	Agrocide dispersible powder* on 126th and 151st. days after sowing at rate of 4 rotls/feddan.
6	BAR. 7/8	Agrocide 3* on 126th. day at rate of 40 rotls/ feddan.
11	Mu 8b.	None-control.
12	BAR. 11/5	None-control.
15	BAR. 13/7	Aldrex 2* on 126th day at rate of 1 rotl/feddan.
19	BAR 7/8.1.	Dieldrex* on 126th day at rate of 1 rotl/feddan.

Footnote *

*Agrocide dispersible powder contains 6.5% gamma benzene hexachloride.

*Agrocide 3 contains 0.65 gamma benzene hexachloride.

*Aldrex 2 contains.

*Dieldrex 15 contains 1.49 pints technical dieldrin per gallon.

Treatment.

The various insecticides were applied to the soil at the time of the final weeding (126th day) and a second application (plot 4 only) made on the 151st day after sowing. The Agrocide formulations were dusted on to the soil and dug into the surface; the aldrin formulations were sprayed on to the soil around the plants.

Method.

Counts of *Dysdercus* spp. on each plot were made by weekly collections of the entire population present from the 100th day after sowing until the end of harvest. Boll samples were collected at regular intervals from each plot from the 12th day after sowing until the end of harvest.

Yield data were recorded. The ratio of seed to lint was determined and tests of seed viability were made, the data for the plots are recorded in table 4.

Table 4.

Plot.	Yield rotls/feddan			% of total		
	Grade A	Grade B	Grade C	Grade A	Grade B	Grade C
Plot 1—BAR. 12/3 C ...	301	158	52	58.9	30.9	10.2
Plot 3—Stoneville 5 C ...	195	191	79	41.9	41.1	17.0
Plot 4—S. 47 T ...	65	111	64	27.1	46.3	26.6
Plot 6—BAR. 7/8 T ...	190	100	61	54.1	28.5	17.4
Plot 11—Mu 8b C ...	181	58	32	66.8	21.4	11.8
Plot 12—BAR. 11/5 C ...	591	169	39	74.0	21.1	4.9
Plot 15—BAR. 13/7 T ...	478	94	10	82.1	16·2	1.7
Plot 19—Bar. 7/8.1 T ...	448	111	26	76.6	19.0	4.4
Average of control plots ...	317	144	51	61.9	28.1	10.0

Grades A and B (Saleable).

Plot.	Total	% of average of controls.
Plot 1—BAR. 12/3 C	459	99.7
Plot 3—Stoneville 5 C	386	83.8
Plot 4-S. 47 T	176	38.2
Plot 6-BAR. 7/8 T	290	63.0
Plot 11-Mu 8b C	239	51.9
Plot 12-BAR. 11/5 C	760	165.0
Plot 15-BAR. 13/7 T	572	124.0
Plot 19-BAR. 7/8.1 T	559	121.0
Average of control plots	461	100.0

N.B.—C indicates control plot and T indicates treated plot.

Table 5 records the analysis of seed cotton from the plots and the result of tests of seed germination.

Table 5.

Records of examination of seed cotton and tests of germination capacity of seed.

	Analysis of seed cotton.						
	Grade A		Grade B		Grade C		
	Seed Lint	Aver. Seed Wt.	Seed Lint.	Aver. Seed Wt.	Seed Lint.	Aver. Seed Wt.	% Viability of seed.
Plot 1-BAR. 12/3 control ...	2.14	.09	2 41	.08	2.27	.07	68
Plot 3-Stoneville 5 Cont. ...	2 40	.08	2.33	.08	2.23	.06	75
Plot 4-S.47 Treated	2.29	.09	2.00	.09	2.13	.09	53
Plot 6-BAR. 7/8 Treated ...	2.04	.09	2.60	.08	1.77	.07	80
Plot 12-BAR. 11/5 Control ...	1.83	.08	2.30	.08	2.06	.07	73
Plot 15-BAR. 13/7 Treated ...	2 31	.08	2.20	.09			88
Plot 19-BAR. 7/8.1 Treated ...	2.17	.10	2.26	.10	2.09	.08	86
Average of control plots ...	2.12	.08	2.35	.08	2.22	.07	72

Comments.

In assessing the value of the results, varietal differences must be taken into account. It must also be remembered that the plots were not sited on uniform soil-vegetation land.

Plots treated with Aldrin formulations both outyielded the average of the control plots and germination tests showed a higher percentage of viable seed from these plots. The Agrocide treatments both had lower yield and the dispersible powder treatment had a lower percentage viability of seed than the average of the control plots.

Dysdercus population levels were below average on the Agrocide treatments and above it on Aldrin treatments. Bollworm infestation was about the average in Aldrin treatments.

Conclusions.

It is probable that any differences in yield can be attributed to differences in variety and or differences in soil.

Experiment on the damage caused to cotton by Helopeltis Schoutedeni.

Layout.

Four small plots each of 12.5 x 12.5 m. were laid out with a belt of 2.5 m. on all sides. The variety of cotton sown was BAR. 11 5 and the spacing adopted 90 x 30 cm. All plots were on virgin land of a similar soil-vegetation type. Two were sown June 15 and the other two July 18. All were maintained according to normal standard Y.E F. practice.

Treatment.

One June-sown and one July-sown plot were isolated from all other cotton and infested with *H. schoutedeni* over a period of days between the 20th. and 25th. day after sowing as shown below :—

June-sown plot 34♀, 13♂ and 3 nymphs. Total 50 insects.
July.sown plot 11♀, 14♂ and 27 nymphs. Total 52 insects.

The July-sown plot was re-infested on the 68th. and 69th. days after sowing, with 9♀, 29♂ and 12 nymphs, total 50 insects, because of the dispersal of the first infestation.

Two other two plots were subjected daily to collections by hand of all *H. schoutedeni* present. All plants damaged by the insects were pulled up and burnt on 32nd, 44th., 58th. and 72nd. days after sowing

Method.

Curves of the population of *H. schoutedeni* were established for all four plots by weekly evening counts. The curves for the June-sown plots were started on the 35th. day and the July-sown plots on the 37th. day after sowing.

All plants in each plot were classified according to the damage of *H. schoutedeni* which they sustained on the 120th day after sowing.

Cotton plant diagrams were made on five plants on each plot. Yield data were recorded. The ratio of seed to lint was determined and tests on the viability of the seed made.

Observations.

H. schoutedeni damage on the infested plots was to be found in patches, which tended to correspond to the points of introduction of the insect.

The method of hand picking appeared to control the insect quite effectively on the other plots.

Results.

Yield data for the four plots are presented in table 6.

Table 6.

Yield data of plots of experiment on damage caused to cotton by *H. schoutedeni*.

Plot.	Yield rotls/feddan			% of total.		
	Grade A	Grade B	Grade C	Grade A	Grade B	Grade C
June infested plot	348	85	45	72.8	17.8	9.4
June hand-picked plot ...	358	92	60	70.2	18.0	11.8
July infested plot	282	191	97	49.5	33.5	17.0
July hand-picked plot... ...	230	60	37	70.4	18.3	11.3
Infested plots, average of total	310	138	71	59.7	26.6	13.7
Hand-picked plots, average of total	294	76	44	71.0	18.3	10.7

The damage assessments are given in Table 7.

Table 7.

Assessment of damage of *H. schoutedeni* sustained by the plots of the experiment.

Plot.	No. of Plant Holes	Infested Plots							
		Not Damaged.		Light Damage		Moderate Damage		Heavy Damage	
		Plants	%	Plants	%	Plants	%	Plants	%
June sown	550	378	68.6	102	18.6	46	8.4	24	4.4
July sown	550	488	88.7	47	8.6	11	2.0	4	0.7
Average :	550	433	78.7	75	13.6	28	5.2	14	2.5

Plot.	No. of Plant Holes	Hand Picked Plots							
		Not Damaged.		Light Damage		Moderate Damage		Heavy Damage	
		Plants	%	Plants	%	Plants	%	Plants	%
June sown	550	474	86.2	51	9.3	19	3.1	6	1.0
July sown	550	519	99.4	11	2.0	11	2.0	9	1.6
Average	550	497	90.3	31	5.6	15	2.7	7	1.4

Discussion.

The July infested plot never had an infestation approaching that of the June infested plot and its infestation was only a little greater than that of the July hand-picked plot. Even the infestation of the June-sown plot was at maximum only 25 insects per 1,000 plants; except immediately after introduction of population which is 50% below the Congo figures for heavy attack (op. cit.). Thus an initial infestation of 100 insects per 1,000 plants did not result in the natural maintenance of a population sufficient to cause heavy damage to the infested plots. Damage assessment counts showed that the June-sown infested plot suffered more heavy damage than the hand-picked plot. There was little difference between damage to the July infested plot and its counterpart. It is not to be expected therefore that the results will show any definite effect of *H. schoutedeni* infestation.

The infested plots outyield the hand picked by 20%. Plant diagrams show that the plants of the infested plots were better developed, carrying more buds and bolls and also a better grade of boll. Seed from the infested plots showed a higher rate of viability than that from the hand picked plots.

Conclusions

The populations of *H. schoutedeni* present on the infested plots did not reach a sufficiently high level to cause serious damage to the cotton. Under normal conditions in the district the level of *H. schoutedeni* populations does not reach that of the infested plots. *H. schoutedeni* is therefore a minor pest and only locally important.

BUD AND BOLL SHED INVESTIGATIONS

Layout

Shed collections were made daily from August 1 to January 3 on the following experimental plots :—

1. The two plots of the experiment to grow cotton free from pests from the five cotton diagram plants in each plot.

2. The Duration and Types of Fallow, Z experiment, G rotation plot 37—from the eight cotton diagram plants. (Comparison Plot A).

3. Cotton early association trial sub-plot 1—from the eight cotton diagram plants. (Comparison Plot B).

4. Cotton variety trial—from one row the width of the sub-plots in two sub-plots of each variety.

5. Cotton seed treatment trial from one row the width of the sub-plots in two sub-plots of each variety.

6. Continuous cultivation methods trial—from one row the width of the sub-plots in two sub-plots of each method.

Method

The collections were examined in the laboratory for insect damage. Every shed collected was sampled and recorded.

Results

P. gossypiella was by far the most common bollworm. It had an incidence of very nearly 10 in the sheds. It is however probable that shed collection examinations do not give a true indication of the incidence of bollworm in the crop. The incidence of *P. gossypiella* in collection of bud and bolls from the plant was greater than that in shed collections.

EXPERIMENT OF HIBISCUS ESCULENTUS AS AN ALTERNATIVE HOST PLANT FOR DYSDERCUS SPP. AND PLATEDRA GOYSSPIELLA.

Layout

25. plots each 18 x 1.5 m. were planted at 15 day intervals from October 1, 1952 to October 11, 1953. The spacing adopted was 90 x 30 cm.

Method

At regular intervals all *Dysdercus* spp. present on ripe fruits were collected and the ripe fruit picked. It was then brought to the Laboratory and examined for damage of *P. gossypiella.*

Collections of the ripe fruits and the *Dysdercus* spp. infecting them were also made on plots of *H. esculentus* belonging to staff of the Y.E.F. and cultivators in neighbouring gharia lines.

Results

No ripe fruit of *H. esculentus* was collected during the month of May, June and July. Apart from those months the incident of *P gossypiella* in fruits from the plot at Y.E.F. rose more or less steadily to a peak of 100% in April infestation. The numbers of fruits collected from the Y.E.F. plot were small and data obtained therefore probably not as reliable as that based on collections from other sources. In the collections the incidence of *P. gossypiella* from October to April was between 14% and 24% except for April when again only a small number of fruits was collected. The peak infestation was in December.

Dysdercus spp. Adults and nymphs of all species were found on the fruits collected. They were never numerous, the greater number of those collected being young nymphs, which were rare on the Y.E.F. plot.

Conclusions

H. esculentus is an important alternative host plant of *P. gossypiella* and from October to April supports an infestation of about 20% of ripe fruits. It is also a host plant, but not an important, one for *Dysdercus* spp. It cannot be of great value for tiding the pests over the dead season for cotton, as ripe fruits are not normally found in May June and July.

Experiments in The District

EXPERIMENTS ON LARGE SCALE CONTROL OF DYSDERCUS SPP. BY A POISON BAIT FORMULATION

Layout

1. Yambio sub-district experiment:—2 village lines in sub-Chief Gbozangara's area. Randomised layout with two treatments, baited and untreated.

2. Ezo sub-district experiment: 6 village lines in sub-Chief Perembata's area. Three lines treated and three control lines without treatment.

3. Maridi sub-district experiment:—6 village lines in sub-Chief Fotombia's and sub-Chief Ngungwa's areas. Three lines treated and three control lines without treatment.

Treatment

The bait formulation used was a mixture of Agrocide dispersible powder and white sugar dissolved in water. The proportions were 11.34 g. Agrocide dispersible powder to 900 g. white sugar.

Treated plots were baited once a week for seven weeks in Yambio trial (October 26—December 12), six weeks in Maridi trial (October 26—December 5), and eight weeks in the Ezo trial (October 19—December 12). Bait was applied before 8.30 a.m. whilst the dew was on the cotton leaf. It is was sprinkled on to the plants, as drops, from sacking dipped in the solution. Two lbs. of the mixture dissolved in one gallon of water was used for treated plots in Ezo and Maridi trial and the half feddan plots of the Yambio trial. The one feddan plots of the Yambio trial were treated with twice this amount of solution.

Method

In Yambio one entomological assistant was posted to the trial to make observations on population levels of *Dysdercus* spp., *H. schoutedeni* and the degree of infestation of *P. gossypiella* in sample treated, and control plots. Individual yields and areas for each plot were obtained. In Ezo and Maridi yield data were obtained at cotton markets.

Results

The yield data for the Yambio trial area given in table 8.

The yield data for the Ezo and Maridi trials are given in table 9 and 10 respectively.

Table 8.

Yield data—Randomised poison bait trial against *Dysdercus* — Yambio sub-district.

Treatment	Area Fedd.	Yield Rotls/Feddan			% Total			Return per Cultivator (Piastres)					Cost of Treatment
		Grade I	Grade II	Grade III	Grade I	Grade II	Grade III	Grade I	Grade II	Grade III	Total	% Control	(P. T.)
Treated plots ...	25	206	46	61	65.8	14.7	19.5	139	23	16	177	81	15½
Control plots ...	28.2	236	52	118	58.2	12.8	29.0	153½	26	29½	209	100	—

Table 9.

Yield data-Poison bait trial against *Dysdercus*-Ezo sub-district.

Treatment	Area Fedd.	Yield Rotls/Feddan			% Total			Return per Cultivator (Piastres)				
		Grade I	Grade II	Grade III	Grade I	Grade II	Grade III	Grade I	Grade II	Grade III	Total	% Control
Treated Plots ...	59	275	94	115	56.8	19.4	23.8	189	47	29	265	90
Control Plots ...	58.5	320	111	123	57.6	20.3	22.1	208	5½	31	294½	100

Table 10.

Yield data—Poison bait trial against *Dysdercus*-Maridi sub-district.

Treatment	Area Fedd.	Yield Rotls/Feddan			% Total			Return per Cultivator (Piastres)				
		Grade I	Grade II	Grade III	Grade I	Grade II	Grade III	Grade I	Grade II	Grade III	Total	% Control
Treated Plots ...	92.1	213	8	50	78.6	3.0	18.4	138½	4	12½	155	89
Control Plots ...	79.8	236	14	60	76.1	4.5	19.4	153	7	15	175	100

Costings. The cost of treatment of an average line, i.e. one of 50 cotton plots or 25 feddans of cotion is set out below —

		£E.	m/ms.
Materials —	Agrocide dispersible powder	0.080	
	White Sugar	0.330	
Labour —	One Article III supervisor at £E. 2.400 m/ms.	4.200	
	Two Labourers ... ... at £E. 0.035 m/ms.	3.430	
	Total	£E. 8.040	m/ms.

An increase in yield of 620 rotls of grade 1 seed cotton (calculated at the present price of 13 m ms. per rotl) is needed to cover the cost of treatment per line. The increase in yield per cultivator must therefore be 12,5 rotls grade 1 seed cotton simply to cover cost of treatment. Including cost of transport of materials and an increased return for the cultivator, the treatment must be regarded as uneconomic unless there is an increase in yield of at least 25 rotls per cultivator of grade 1 seed cotton.

Remarks

In the 1952 trial the return to the cultivator from a treated plot was 128% of that of the control, and the yield was 98 rotls per feddan higher giving an increase in value of approximately 35 pt. after deduction of the cost of treatment.

The return to the cultivator from the treated plots of the 1953 trials was 81% 90% that of the control plots and the yield was 39—93 rotls per feddan lower giving a decrease in value averaging 35 pt. after deduction of the cost of treatment.

In 1952 a year of average infestation, treatment reduced *Dysdercus* but in 1953, a year of light infestation it did not. Both years the proportions of the three grades of seed cotton in the yield from treated and control plots were similar.

Recommendations

As the reduction in the more exactly controlled 1953 trials indicated that the treatment was economically valueless in a year of light *Dysdercus* infestation and as it is possible to gain an idea of probable level of infestation only in early October it is recommended that this approach to control of *Dysdercus* be abandoned.

BUD AND BOLL SHED INVESTIGATIONS.

Method

Ezo sub-district. All sheds were collected daily from the cotton observation plot (approximately 10,000 plant holes) at Yengi-Yeng cotton market near Ezo from August 1 to December 26.

Maridi sub-district. All sheds were collected daily from a cultivators plot (approximately 9,000 plant holes) in Iba from September 14 to December 21.

Seven bags containing sheds for each day of the week were sent weekly to Y.E.F. and examined there for insect damage. All sheds collected were sampled and recorded.

Comments :

P. gossypiella was by far the most common bollworm, having an incidence of 10% in Maridi collections and 12% in Ezo collections, which shows a level of infestation similar to Y.E.F.

AN INVESTIGATION INTO THE EFFECT OF GOOD COTTON HYGIENE ON YIELD AND ON PEST LEVELS.

Layout

One village line near Yambio geographically isolated from its neighbours in which all cultivators practised good cotton hygiene. The nearest line to it, in which the cultivators adopted their normal cotton hygiene procedure, was utilised as a comparison.

Method

Supervision of the pulling of stalks and of the disposal of cotton debris began in February. The campaign was conducted with the help of the sub-Chief and the village headman.

Population samples of *Dysdercus* spp. and *H. schoutedeni* were made on a plot prior to the commencement of the hygiene campaign and the infestation of *P. gossypiella* in the plot was ascertained by sampling of boll collections. Counts of the populations of *Dysdercus* spp. from September 4 to March 12, and of *H. schoutedeni* populations from July 31 to March 12, were made on sampling plots in the 'hygiene' line and in the neighbouring line. Boll collections were taken from the plots from October 16 to March 12, and examined for damage by *P. gossypiella*.

All cotton plots of the 'hygiene' line were sown before the end of June. Yield data for both lines were obtained from cotton market records.

Observations

The hygiene did not prove very satisfactory. 90% of the cultivators had completed the cleaning of their old cotton plots by the end of March but cleaning by the other 10% was not fully complete until May 7. The cotton dead season in the line therefore, even amongst the best cultivators was only two to two a half months in duration and amongst the worst was only one month.

Results

Yield data is presented in table 11.

Table 11.

Yield data of 'good hygiene' and its comparison gbaria (seed cotton).

	Area of Line (Fed)	Yield Rotls/feddan			% of total			Yield % of Comp.
		Grade I	Grade II	Grade III	Grade I	Grade II	Grade III	
Diaborongba (Hygiene) ...	23.7	295	—	35	89.4	0	10.6	64.5
Kpawa (Comparison) ...	19.2	398	9	105	77.8	1.7	20.5	100

Discussion

Unsatisfactory as the hygiene was, it appeared to reduced the initial infestation of *P. gossypiella* though its level at the end of the season was above that of the comparison gbaria. The *H. schoutedeni* population levels were very similar in the two lines. The *Dysdercus* population in the hygiene plot became twice that of the comparison plot. The comparison gbaria produced a higher yield of seed cotton in each grade.

Conclusion

The enforcement of 'good cotton hygiene' probably reduced the level of *P. gossypiella* in the line but had no effect on *Dysdercus* spp. of *H. schoutedeni*.

Observations on Agronomy Experiments at Y.E.F.

OBSERVATIONS ON THE EFFECT OF CERTAIN AGRONOMY TREATMENTS ON POPULATIONS OF COTTON INSECTS.

Site

The observations were carried out on plots of two Agronomy experiments:—

1. The cotton opening and sowing date and weeding experiment.
2. The cotton early association and weeding experiment.

Treatments

In the first experiment the factors contrasted were, early opening and normal, June sowing and July sowing, and weeding at 20, 40, 70 and 130 days and clean weeding throughout the season.

Those contrasted in the second experiment were, cotton grown in association with legumes and cotton in pure stand, and weeding at 20, 40, 70 and 130 days, at 20, 70, 130 days and clean thereafter, and clean weeding throughout the season.

Method

50% of the plots of experiment 1. were sampled and 40% of those of experiment 2. Weekly counts of insect populations were made For *H. schoutedeni* from July 23 to December 17 and for *Dysdercus* species from September 15 to December 29. Bolls were collected from the plant and examined for *P. gossypiella* incidence at regular intervals from October 20 to December 29.

Comments

The infestation of *P. gossypiella* was fairly consistently 5% — 10% higher in the treatment imitating cultivator's weeding than in clean weeding or standard Y.E.F. weeding treatments. The latter treatments had fairly similar infestations. *P. gossypiella* infestations showed only small differences between the other treatments contrasted.

The *H. schoutedeni* population level was higher on the June-sown than on the July-sown treatments. The populations in all cases were small and there was little difference between other contrasted treatments.

The population level of *Dysdercus* spp. was higher on normal opening treatments than early opening ones; on June-sown treatments than July-sown ones; on cotton with associate crop than cotton in pure stand; and on clean weeding and pseudo-cultivator weeding treatments than standard Y.E.F. weeding treatment. The most marked difference was in the last contrast of treatments. The most obvious correlation was that greater numbers of *Dysdercus* were present on heavier yielding cotton. The early opening treatment out-yielded the normal opening one, the population levels being slightly higher on the former until the end of the season when there was a great increase on the latter.

Conclusions

Plots with greater weed growth tend to support larger populations of *P. gossypiella* and *Dysdercus* spp. in the crop. Treatments resulting in larger yields of cotton tend to support larger populations of *Dysdercus* spp. on the crop.

Laboratory and Observational Work.

Laboratory trials of various poison bait formulations against Dysdercus Superstitiosus.

Formulations

The formulations listed below in table 12 were used in the experiment.

Table 12.

Poison bait formulations tested against *D. superstitiosus* in wire cages.

Description of Bait.	Formulation.
1. BHC-white sugar ...	0.5g. Agrocide dispersible powder: 39.7 g. white sugar: 205 ml water.
2. BHC-white sugar, double strength	1.0g Agrocide dispersible powder: 39.7 g. white sugar: 205 ml. water.
3. DDT-white sugar ...	1.0g. 50% DDT dispersible powder: 39.7 g. white sugar: 205 ml. water.
4. DDT-jaggery sugar ...	1.0 g. 50% dispersible powder: 39.7 g. Sakure sugar: 205 ml. water.
5. Aldrin-jaggery sugar ...	10 ml. Aldrex No. 2 39.7 g. Sakure sugar: 205 ml. water.
6. Dieldrin-jaggery sugar ...	10 ml. Dieldrex 15 : 39.7 g. Sakure sugar: 205 ml. water.
6. DDT-cotton seed meal ...	1.0 g. 50% DDT dispersible powder: 40.0 g. cotton seed meal: 205 ml. water.
8. Aldrin-cotton seed meal ...	10 ml. Aldrex No. 2: 40.0 g. cotton seed meal: 205 ml. water.
9. Dieldrin-cotton seed meal ...	10 ml. Dieldrex 15 : 40.0 g. cotton seed meal: 205 ml. mls. water.
10. Dieldrin-white sugar ...	2.1 ml. Dieldrin wettable powder: 39.7 g. white sugar: 205 ml. water.

N.B.— In white sugar and jaggery sugar formulations the ingredients were dissolved together. In cotton seed formulations the insecticide was dissolved and the meal placed in the solution. Results Formulations 2, 4, 9 and 10 all gave better kills of *D. superstitiosus* than the formulation 1, which has been used previously.

BIONOMICS AND SEASONAL HISTORY.

Stainer bugs. Dysdercus superstitiosus and *D. nigrofasciatus*, have been reared in the laboratory on damp seed in 18 inch cube wire cages or 6 x 12 inch glass cylinders. The results to date of this work are given in table 13.

Table 13.

Results of rearing *Dysdercus* spp. in the Laboratory. Length of Stadia in days.

SPECIES.	Type of Food.	Incubation. Days	Average Duration of Stadium					Total Duration egg to adult	No. of Batches raised maturity.
			1st inst.	2nd inst.	3rd inst.	4th inst.	5th instar		
D. superstitiosus	Cotton seed	6-7	3-4	4	4-5	6	10-14	36-37+	21
,, *nigrofasciatus*	,,	8	3-4	5	4	6	12	38+	29
,, ,,	Bamia	7	3	2	6	7	14	39+	3
,, ,,	Kapok	8	4	3	8	4	11	38+	1

N.B. + Total duration egg to adult figures are weighted means.

The following is resumé of what has been discovered of the seasonal history. Cotton is invaded during September and the first breeding in the crop takes place towards the end of that month. Numbers of adults and nymphs increase with the ripening and opening of bolls until about the end of November, when adults begin to leave the crop for *Sterculia tomentosa* which is ripening. A large population composed almost entirely of nymphs remains on the crop until the enforcement of hygiene about March. Ripe fruits remain on *S. tomentosa* during December, January and February and are then shed. The stainers continue to feed on the ripe and rotting fruit whilst it is on the ground. During February *Ceiba pentandra* Gaertn. (Bombaceae) (Kapok) begins to ripen and adults and nymphs are to be found on the tree and on dropped fruits from then until July. *Dombeya* spp. (Sterculiaceae) fruits during February and the fruits rot quickly so the stainers are found only transiently at that time upon the shrubs. Both adults and nymphs can be found in small numbers on cultivated *Hibiscus* spp. during December, January, February and March after which the plants are no longer in the field. Feeding takes place on ripe fruits particularly of *H. esculentus*, (bamia) but also of *H. cannabinus* (kenaf) and *H. sabdariffa*. Nymphs have been taken on rotting fruits of *Coloncoba schweinfurthii* Gilg ? (Flacourtiaceae) during January.

The host plants for the period July-September are unknown. As very little bamia is in cultivation before October, the only possible *Hibiscus* spp. would be wild ones and these are not common in the bush. The most likely hosts during this period would appear to be dropped and rotting fruits of *S. tomentosa* and possibly kapok, and standover, ratoon and volunteer cotton plants which are bolling from March-April onwards.

Relative humidity and the severity of the dry season are important factors affecting the size of *Dysdercus* spp. populations (see section 1 of the report).

Helopeltis schoutedeni.

Attempts to rear *H. schoutedeni* in the laboratory have been unsuccessful. The capsid is present on cotton from the cotyledonary stage (late June) until the bolls are ripening and opening (November). There are two population peaks, mid-August and late September, but it is only very locally that the population rises above a low level. The following plants have been found to be host plants:—

Cissus populnea Guill and Perrott (Ampelidaceae) *Jussiaea abyssinica* (A. Rich) Dandy and Brennan (Onagraceae), *Polygonum limbatum* Meisn. (Polygonaceae). Feeding has been observed on *Sarcocephalus esculentus* Afz. (Rubiaceae), *Mangifera indica* L. (Anacardiaceae) and *Acalypha* spp. (Euphorbiaceae).

The host plants for the period December-June are unknown. Specimens have been taken on *J. abyssinica* and *P. limbatum* during January. Out of season cotton would appear to play no part in the insects survival, and it seems most likely that these two marsh plants are the main and even the only host plants during this period and that they support a very small population.

Platyedra gossypiella. No attempt has yet been made to rear pink bollworms in the laboratory. The larvae are present in the crop from the begining of budding (early August) until the enforcement of hygiene measures about March. A peak of infestation has been observed in December-January as shown in table 14 below but other figures have shown a steady increase in population to the end of the crop.

Table 14.

% infestation of *P. gossypiella* in collections of bolls picked from the plants.

Month.	Oct.	Nov.	Dec.	Jan.	Feb.	March
% Infestation ...	15.3	51.1	34.2	66.8	60.2	53.9

Bamia is the only alternative host plant known and ripe fruits are infested throughout the growing season from October to April. During the period April—August very little bamia is cultivated. Wild bamia has not been observed. It is therefore almost certain that the source of carry over of the pest is standover, ratoon and volunteer cotton. Bolls from such plants always show a percentageof infestation whenever they are examined.

Conclusions.

The results of the year's investigations have confirmed that *Dysdercus superstitiosus* and *Platyedra gossypiella* are the major pests of cotton in Zande District. *Helopeltis schoutedeni* has been shown to be a minor pest, its population throughout the district is at too low a level, except very locally, to cause serious damage to the crop.

CENTRAL RAINLANDS RESEARCH STATION

(Tozi Research Farm)

by A. H. Bunting.

Development of the Station

The area of the farm was expanded from 250 to 666 feddans approximately, lying in three roughly square blocks. Each block was divided into 16 square fields by a grid of field roads. The areas of these fields were from 12 to 14 feddans depending on the size of the blocks : this field size has been found convenient both in experimental work and field scale cropping.

Four permanent laboratory and office buildings were erected and partly equipped and occupied. The canal from the Blue Nile (11 km.) was completed and put into service with a temporary pumping station in June 1953. A workshop, farm office, dairy and cowshed were completed or nearly completed in the first half of 1954.

The senior staff of the station at 31.12.1953 was as follows :—

A. H. Bunting	.. Senior Research Officer
J. R. H. McCallum	.. Agronomist.
P. D. Walton	.. Plant Breeder.
W. S. Richards	.. Entomologist.
P. K. S. Clinton	.. Plant Pathologist.
J. D. Lea	.. Botanist.
J. F. Rooke	.. Research Engineer.

The Season.

The 1953 rains at Tozi were about 100 mm. lighter than the expected average of 700 mm., and they were distributed in such a way that the last weeks of the season were markedly dry. Effective rains began during May (59 mm.) and 84 mm. were received in June. Planting began early in July, in which month 165 mm. were recorded. Up to this point the season had been rather wetter than 1952 (the first year at Tozi), but in August 1953 183 mm., and in September 71 mm., were received compared with 265.5 and 137.5 mm. respectively in 1952. Nevertheless the August rains, which included a fall of 53 mm. on 21 August, caused flooding in certain slightly low-lying areas. The broad data are in table 1.

Table 1.

Monthly rainfall, Tozi main gauge, May-October,

1952 and 1953.

1. Rainfall:—	May	June	July	Aug.	Sept.	Oct.	Total
Rainfall, total, mm.	20.0	73.0	137.0	265.5	137.5	33.5	702.5
Maximum fall, mm.	12.5	20.5	58.0	50.0	44.0	33.5	58.0
Rainy days	2	7	11	15	10	1	46
1953							
Rainfall, total, mm.	59.0	84.0	165.5	183.0	71.0	27.5	590.0
Maximum fall, mm.	21.5	21.5	45.0	55.0	24.0	17.0	55.0
Rainy days + ...	4	8	11	13	6	5	47

+Traces of rain not counted.

From 12 August onwards readings were taken from a grid of 8 gauges at kilometre intervals in two directions in addition to the principal gauge. The individual storms showed regular isohyetal patterns on the grid, but on the whole the distribution for the period studied was random. Variability of the daily totals was inversely related to their size.

The rains temperatures were around 30°C max. and 20°C minimum (July to late September). During this period the dew point was round 20°C. Day temperatures rose in late September and October as the cooling rains faded away. The dew point fell sharply with the arrival of dry northern air on 24-25 October (the same date as in 1952). After this time minima also fell away, reaching 7.7°C on the coolest night of December. Maxima rose to around 40°C. in November; they were somewhat moderated in December and January, which were on the whole cool months, and rose again for the hot months of March and April before the oncoming of the new season once more brought them down. The temperature and humidity characteristics of the 1953 season are shown in table 2.

Temperatures and dewpoint, Tozi, June-December,

1953.

	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Max. temp. °C. highest ...	38.2	37.0	32.9	36.6	39.0	40.0	39.9
,, ,, lowest ...	32.2	21.8	28.0	28.5	28.4	32.1	31.0
,, ,, mean ...	35.1	30.8	30.6	33.0	36.2	37.0	33.8
Min. temp. °C. highest ...	23.8	27.5	22.6	21.8	22.5	23.0	18.5
,, ,, lowest ...	19.0	18.3	19.5	18.6	12.5	11.3	7.7
,, ,, mean ...	21.1	21.1	20.5	20.3	18.3	17.3	13.5
Dewpoint °C. highest ...	23	23	24	24	22	20	12
,, lowest ...	19	19	19	18	5	−1	−8
,, mean ...	20	21	21	21	17	9	3

Work under this heading was conducted by the Botany Section. A road reconniassance covered over 400 miles in the area from Jebel Moya to the Ingessana hills and the Blue Nile. A broad general assoc-ation of darker coloured clays—in the range brown,grey - brown, grev, with wetter conditions due to topography or higher rainfall, was indicated. The situation of the highly friable and more permeable fuda clays, which resemble the normal (badob) clays in most obvious respects except the depth of the surface friable layer, is not so far explained.

Tozi has no fuda soils, but otherwise contains all but the brownest of the badob types, according to topographical situation. At 5-6 feet the darker surface clay merges into a brown or reddish brown horizon, mottled with darker material. At 16 feet the clay lightens in colour, becomes more sandy, and gives way to sand at 19 feet. The sand appears to have been deposited or redistributed by water. Calcium carbonate nodules are present throughout the profile, but have bands of concentration at 10-12 feet in the clay, and in the sand, where dis-tinct dense layers of blackened nodules are seen. The sand contains root-like structures, lightly cemented (with iron ?) : similar structures, fossilised with calcium carbonate, may be seen in the river banks at Tibna near Wad en Nail.

Chemical and physical properties.

The Tozi clay is completely structureless and plastic when wet. As it dries out after rain a point is reached when the soil mass, to a depth of a few inches, or throughout a ridge, quite suddenly becomes structured, crumby and friable. It then has sufficient strength to support men and machines. The crumbs are very strong when completely dried but have no stability whatever in water.

Chemical analysis (table 3) of 60 surface soil samples have given a general picture of a heavy, alkaline soil, with relatively low salt content and sodium values. The modal pH range is 9.0 to 9.2, but the beter agricultural soils (on grounds of texture) lie below the modal range, from pH 8.5 to 9.0 or 9.1 The salts and sodium values are rather low, with means of 0.053% and 14 respectively ; here again the more useful soils have values below the mean. The clay content averages 68% Nitrates in the soil averaged 3 p.p.m. and this mean value was not increased on incubation. The mean carbon content of 0.41% suggests an organic matter content below 1%. The nitrogen values (340-630 p.p.m., with mean of 470 p.p.m.) indicate a C N ratio of around 10. indicating a stable organic complex with no recent additions of raw organic matter. The more useful soils are lighter in colour (dark and very dark grey-brown) than the less satisfactory greys of the lower situations.

Table 3.

Results of Chemical analysis of 60 Tozi soil samples, surface foot, 1953.

	Range	Mean value or modal range.
pH Glass electrode, 1 : 5	8.5–9.6	9.0–9.2 (47%)
Exch. Ca : mg.e./100g	9–30	21
Salts %	0.024–0.105	0.053
Na value (exch. + sol. Na: mg.e. /100g. clay) ...	2–31	14
P_2O_5 ppm. (Truog)	30–400	116
N, ppm.	340–630	473
C, % Walkley Black x 4/3	0.31–0.67	0.41
Clay %	55–77	68 (1 sample 44%)
Nitrate in fresh soil, p.p.m.	1–11	3.4
,, after 10 days incubation p.p.m.... ...	1–16	3.3

Colours : most common is 2.5 Y/5;2 : grey brown on the Munsell scale the remainder being various types of grey.

Soil Management

The 2-inch storm of 21 August fell after a fairly wet period. The capacity of the soil to absorb this further fall was inadequate and localised run off led to much local flooding and some movement of soil over short distances, even on the practically flat land of Tozi. The control of flooding will evidently be a serious problem on the area. There can be no question of general levelling, since the cost would be high and the accuracy required extremely high. The solution may lie in measures of surface drainage. Two fields were put out in 12 foot plough ridges (broad lands) but it is also possible that simple ridging may provide the answer. Some results of the agronomy section suggest that even where flooding did not occur, planting on the ridge was beneficial to cotton. This may be particularly important on bare fallow fields, which do not crack extensively (since there is nothing but surface evaporation to remove the water) and may lie wet in the all important early weeks of the season, so leading to run off.

Soils of the Wad El Hur (Gedaref) area

The Tozi terrain is so flat that a metre rise or fall per kilometre is exceptional and defined drainage channels are extremely rare. In the Gedaref area the topography of the plain is dissected and rolling, with falls in some places of several metres per kilometre, and drainage channels which in a wet year may discharge to the Rahad river. The Tozi clays are more alkaline than those of Huri (pH around 8), which also have a warmer colour in comparable situations, related no doubt to their lower actual and effective rainfall.

It is suggested that the Tozi soils are more recent and have not suffered redissection since they were deposited, while the Huri topography has been dissected since the deposition of the clay over the basalt-sandstone-basement complex countryside, which is now reappearing as the clay is removed. It is possible that the original deposition was not uniform, but resulted from drainage varying from time to time in amount and position, as erosion and alterations in the course of the outflows from the Abyssinian massif took place. The present topography of the upper reaches in the Sudan of the Rahad and Dinder shows what could have occurred.

The more modern dissection presumably occurred in a period wetter than the present, since the present tendency is towards infilling of the drainage. The flow in most years is insufficient to prevent silting.

There are also in the area basalt ridges, particularly towards the Eritrean frontier, which generate their own soils closely resembling, in the field, the clays of the plain. It appears most unlikely that the latter have been formed by local weathering, in general, since the clays overlie all types of rock and the ridges of the plain occupy a common level over many miles. The rolling topography of the area leads to considerable runoff which causes surface wash and some erosion, and must reduce crop yields by reducing the water available for percolation,

Fertiliser studies.

The yield results of four experiments testing the response of cotton. sorghum, sesame and safflower to fertiliser nitrogen at 0.2, 0.4, 0.6 and 0.8 cwt. per acre as broadcast sulphate of ammonia are summarised in table 4. None of the responses was striking. In cotton, yield was raised from about 1110 r.p.f. seed cotton to 1180-1190 r.p.f. by 0.2 to 0.6 cwt./N feddan; 0.8 cwt. gave rather less. The yield of sesame was increased from 700 to 800 r.p.f. by 0.6 or 0.8 cwt. N, but this may well have been a population effect. In sorghum yields increased from 1750 r.p.f. without N to 1860 with 0.4 cwt. N/feddan; at higher rates of application the yields declined again to 1750 r.p.f. at 0.8 cwt. N. There was no consistent effect of N. on the yield of safflower, which averaged 410 r.p.f.

The fertiliser apparently accelarated flowering in cotton, where the first pick was increased from 47 to 53% of the total by 0.4 cwt. N/feddan.

Table 4.

Effect of nitrogen fertiliser at various rates on the yield and plant population of various crops, Tozi 1953.

N level cwt./fedd.	Cotton	Sesame	Sorghum	Safflower
I. Yield, r.p.f.				
None	1107	699	1750	430
0.2	1191	753	1810	420
0.4	1178	768	1860	370
0.6	1191	802	1800	410
0.8	1163	805	1750	410
Mean	1166	755	1800	410
II. Population, 000 feddan:—				
None	13.9	54.8	11.3	54.8
0.2	13.7	63.2	11.7	61.1
0.4	13.1	66.0	11.6	58.4
0.6	13.6	70.9	12.7	48.5
0.8	13.6	92.5	11.7	58.4
Mean	13.5	58.6	11.8	60.0

Similar rather unimportant reponses to nitrogen fertiliser were given in certain other experiments on cultural methods (see agronomic section of this report) in which 0.4 cwt. N/feddan was included as a variable.

A second series of fertility experiments, of factorial design, measured the effects of all combinations of N (0.4 cwt.) P (0.4 cwt. P_2O_5) and K (0.6 cwt. K_2O) on cotton, sorghum, sesame and groundnuts, and of sprayed Fe and manganese in groundnuts and sprayed Fe and magnesium in cotton. No effects of the minor elements on yield were found. The most striking effect was a response to nitrogen in groundnuts in an experiment in which a darker colour and better growth on the N plots was evident particularly in the earlier stages of the crop. The fertiliser increased the yield of pods from 1405 to 1565 r.p.f. The colour difference disappeared at about 6 weeks : at this stage the nodules, which are profusely formed, had presumably begun to senesce and so to release nitrogen to the crop, which in its earlier days had to forage for itself, a task at which, being a legume, it was apparently not very efficient. The paradox is thus reached that the groundnut at Tozi responds to nitrogen because it is a legume. Its life span at Tozi is just over 90 days : the time remaining after senescence of the nodules begins is too short for the initial check to be made good.

Other effects of interest in these experiments were a response to phosphate in sesame, where it raised yield from 710 to 775 r.p.f. in an experiment in which effects of both N and P were evident in the earlier stages of growth; and an improvement in population in a poor stand of sorghum from 4.85 to 6.94 thousands of plants per feddan, with an accompanying yield improvement from 1130 to 1430 r.p.f. In the cotton experiments, with a mean yield of 764 r.p.f., in a somewhat late planted crop, no important effects of any of the fertilisers were found.

In general nitrogen responses in 1953 were markedly less than in the same crops in 1952, a wetter year.

Observations in trial plantings of Virginia and Turkish tobacco indicated that on the Tozi soils the nitrogen-potash ratio tends to be sufficiently high to give symptoms of potash deficiency which are accentuated by N.P. treatments and alleviated by K, particularly in the absence of N. The possibility of controlling this balance, which is important for quality, by growing the crop on nitrogen-poor land (after heavy preceding crops of sorghum or cotton) with heavy K dressings, seems worth examining.

Agronomy

The work at Tozi in 1952 suggested that, of the many crops tried, American Upland cotton, sorghum, groundnuts, sesame and safflower were likely to be the most useful. Much of the agronomic work of the second season, in 1953, was devoted to the study of the cultural requirements of cotton, groundnuts and sesame. Apart from fertiliser questions (see above) the matters investigated were sowing date and optimum population.

Cotton.

In all experiments on cotton the variety BAR. 7/8.1 was used. The effect of six planting dates from 28 June to 6 September, with a nitrogen fertiliser treatment at each date, was measured in a trial whose results are summarised in table 5.

The populations established were both low and variable but the yields, ranging from 1370 r.p.f. seed cotton from the earliest planting to 400 r.p.f. at latest, leave no doubt that the earlier cotton is planted at Tozi the better, even though some of the later planting gave remarkably good yields. Nitrogen had no consistent effect on yield. A second trial (table 6) examined the effect of varying populations from 4 to 20 thousands per feddan in 36 in. rows on the yield of cotton planted on 19 July. At 4000 plants the yield was 875 r.p.f. seed cotton, of which 21% was in the first picking, while at 20,600 plants it was 1360 r.p.f. with 48% in the first picking. The yield/population curve was exponential in form with no evidence of decline in the range examined.

Table 5.

Effect of six planting dates, each with and without nitrogen, on the yield and plant population of cotton Tozi, 1953.

Planting date.	No. N	N	Effect of N.	Mean
1. *Seed Cotton r.p.f.*	(±48.7) [a]		(±68.9) [d]	(±34.4) [b]
28 June	1388	1347	—41	1367
9 July	1213	1165	—46	1189
26 July	923	1091	+168	1007
11 August	745	770	—25	782
26 August	921	847	—74	884
6 September	406	400	— 6	403
Mean	(±19.9) [c] 941	936	— 4	939
Least significant differences :—	a	b	c	d
5 %	140	99	57	198
1 %	188	133	77	
0.1 %	249	176	101	

Table 6.

Effect of six plant populations on the yield and size of early pickings of cotton Tozi,

1953 (CR/10/53).

Intended population 000/feddan.	Actual popula. 000/fed.	Total yield r.p.f.	1st picking r.p.f.		1st & 2nd picking r.p.f.	
			Actual yield	% of Total	Actual yield	% of Total
	(±0.30)	(±92.8)				
5	4.0	875	182	20.7	506	57.8
10	6.4	986	301	30.6	694	70.2
15	10.5	1228	484	39.2	919	74.4
20	13.5	1303	556	42 8	1024	78.6
25	17.2	1340	659	49.2	1102	82.4
30	20.6	1359	653	48.2	1051	77.5
Mean	12.1	1182	473	40.0	882	74.6

Least significant differences.	Actual populations	Total yield r.p.f.
5 %	0.87	123
1 %	1.17	165
0.1 %	1.54	218

GROUNDNUTS.

The variety used was Natal Common, a short season upright bunch type. In an experiment, plantings on 9 and 23 July gave 8-900 r.p.f. of kernels; later plantings were below 650 r.p.f. The populations were variable, but the results suggest a critical date towards the end of July. In another experiment (table 7) planted on 12 July populations ranging from 16,500 to 53,600 plants per feddan were compared. Even at the latter level maximum yield had apparently not been reached, though the relationship was exponential in form and further increases would probably have been slight. The optimum date of harvest was studied by means of serial harvests in a randomised block design, indicating maximum yield at 90 days from sowing. One third of the final kernel yield was laid down in the last 15 days. These results confirm those obtained at Tozi in 1952.

Table 7.

Effect of six plant populations on the yield of groundnuts, Tozi 1953 (CR 9/53).

Plant population 000/feddan Intended	000/feddan Actual	Kernels r.p.f.	Shelling %
	(± 1.9)	(± 34.0)	
19	16.5	873	68
29	21.9	886	68
39	33.7	1048	69
50	38.4	1025	69
60	47.5	1094	68
70	53.6	1113	69
Mean	39.0	1008	68
Least significant differences			
5 %	5.6	98	
1 %	7.5	131	
0.1 %	9.9	173	

Table 8.

Effect of date of harvest on the yield of Natal Common groundnuts, Tozi, 1953.

Date of harvest.	No. of days from planting.	Plant Population 000/feddan	Yield of harvest/kernels
			(± 25) r.p.f.
13 Oct.	75	21.9	552
18 Oct.	80	23.0	635
24 Oct.	86	22.9	749
28 Oct.	90	23.5	832
2 Nov.	95	22.9	790
7 Nov.	100	22.7	778
12 Nov.	105	19.1	759
17 Nov.	110	20.8	789
Significant differences:—			
5 %			71
1 %			95
0.1 %			124

Sesame.

The variety used was the Fung local heavy black type. Six dates of planting, from 27 June to 16 August, were compared. The highest yield, 820 r.p.f., was given at the first date, and the decline in yield was most marked after 15 July, the last planting giving 90 r.p.f. only. At each date the effect of nitrogen fertiliser (0.4 cwt N/feddan as sulphate of ammonia) was tested, but the responses were negligible. A further trial compared populations ranging from 26,000 to 145,000 plants per acre in 18 in. and 36 in. rows. At the higher levels of population, the less intense competition of the young plants in the narrower rows resulted in better populations, and the yields were also better in these rows for comparable populations. The optimum population was about 100,000 plants per feddan, at which level the yields were about 870 r.p.f. in the closer rows and 770 r.p.f. in the wider ones.

Crop sequence experiments.

A large and somewhat complex experiment measured the effect of a number of crops and cultural treatments applied in 1952 on sorghum grown in 1953. The 1952 crops and treatments were groundnuts lubia, sorghum, safflower, sesame, bare fallow and tumbledown fallow: the non-legumes and the fallowing treatments being sown or applied both with and without sulphate of ammonia at 0.4 cwt. N per feddan on separate plots. In 1953 sorghum was sown over the whole area and the plots were split for a further similar dressing of sulphate of ammonia, to provide a measure of the residual nitrogen effects. Space does not permit discussion of the full data, but the salient points are to be found in table 9. None of the effects of nitrogen applied in either year was significant, though there was some suggestion that on the former bare fallow plots N applied in 1952 was effective, though a second dose given in 1953 depressed the yield again. The N effects have been omitted from the table for the sake of simplicity.

Table 9.

Effect of various crops and cultural practices applied in 1952, and of fertiliser N applied in 1953, on the yield and population of dwarf sorghum, Tozi 1953.

1952 treatment	1953 O	1953 N	Mean	Mean O & N (1952)
I. Grain r.p.f.	(± 78)b		(±63)a	(±63)a
Groundnuts	1570	1570	1570	1570
Lubia	1300	1450	1380	1380
Soghum	1030	1150	1090	(±45)c
Sorghum & N.	1230	1240	1230	1160
Safflower	1310	1240	1270	
Safflower & N.	1130	1150	1140	1210
Sesame	1490	1450	1470	
Sesame & N.	1520	1600	1560	1520
Bare fallow	1340	1580	1460	
Bare fallow & N. ...	1590	1460	1530	1490
Tumbledown fallow ...	1490	1400	1450	
Tumbledown f. & N. ...	1430	1370	1400	1420
Mean	1370	1390	1380	1380
II. Population, 000/feddan :—				
	(± 0.87)e		(± 0.73)d	(± 0.73)d
Groundnuts	13.7	14.7	14.2	14.2
Lubia	12.3	12.1	12.2	12.2
Sorghum	9.8	9.9	9.9	(± 0.52)f
Sorghum & N.	10.5	10.1	10.3	10.1
Safflower	11.0	10.8	10.9	
Safflower & N.	9.9	10.4	10.1	10.5
Sesame	13.1	13.3	13.2	
Sesame & N.	12.1	13.9	13.0	13.1
Bare fallow	14.0	14.6	14.3	14.1
Bare fallow & N. ...	14.1	13.8	13.9	
Tumbledown fallow ...	11.3	11.2	11.3	10.7
Tumbledown f. & N. ...	10.3	10.1	10.2	
Mean	11.8	12.1	12.0	12.0

Least significant differences.

	a	b	c	a-c.	d	e	f	d-f.
5%	180	220	130	150	2.05	2.45	1.46	1.77
1%	240	290	170	200	2.72	3.25	1.94	2.35

Considering first the yield data, the best preceding crop for sorghum was groundnuts, with sesame coming next, provided nitrogen had been given in 1952. The barefallow was also good so long as N was given either in 1952 or 1953 (but not both). The barefallow treatment however checked sorghum growth in the seed bed, probably because the plots became waterlogged, but the excess water enabled the crop to live longer on these plots than elsewhere, so that the yield was made up.

These effects were partly due to effects on population. In most cases effects of nitrogen on establishment were small. Compared with previous sorghum, safflower or tumbledown fallow (10,100 to 10 700 plants/feddan), previous groundnuts or bare fallow greatly improved the stand to over 14,000 plants, while sesame gave 13,000. (All these populations were however far lower than the 50,000 to 60,000 plants/feddan indicated as optimal in 1954, which accounts for their almost linear effects on yield). The nature of the biological effects responsible for these differences in stand is not known.

In so far as fertility effects can be dissociated from population effects, tumbledown fallow was the most benefical treatment raising grain per 1000 plants from around 110 to 133 rotls. Tumbledown fallow is however agronomically an undesirable treatment, as it increases weeds and would be dangerous in field practice Weeds were of course strictly controlled in the experiment. Another point of interest is the beneficial effect of sesame, which is traditionally regarded in the Sudan as a beneficial precursor for sorghum, perhaps due to its incomplete extraction of water because of its limited rooting depth.

The results support the tentative rotation at present in use at Tozi, in which sorghum follows groundnuts.

Four new experiments of this type were started in 1953 for cotton sesame, sorghum and groundnuts in 1954.

Plant Breeding and Introduction.

Work in these fields at Tozi in 1953 was directed to the study of the wide range of material available in sorghum and the development of combine adapted varieties of this crop ; to the yield testing of cotton varieties ; the selection of kenaf (deccan hemp) varieties ; the classification and testing of groundnut varieties ; the improvement of sesame varieties including work on indehiscence ; and some work on maize, safflower, sunflower, soya bean, tobacco and castor was also included.

Sorghum.

In 1953 the greater part of the Evelyn collection of Sudan and other sorghums (554 types), 62 varieties from Southern Rhodesia and 50 Fung local varieties were added to the collection which thus came to number about 800 accessions in all,of which a number are duplicates. An interim classification was drawn up for local use.

The Fung material consisted largely of Wad Akr and Bahana types, and a number of varieties were of dwarf stature (4½ ft. or less). Some of these were selected for the combine breeding programme (see below). In observation rows yields up to 1970 r.p.f. were obtained from such types. A formal trial sown on 24 July compared 14 introduced combine sorghums with Wad Beshir, one of the best Sudan dwarfs, and P41, a Swaziland medium stature type. The results are in table 10. Wad Beshir and P 14, with around 2700 r.p.f., gave best yields and were followed by four introductions giving 2200—2550 r.p.f.—Ladone, Plainsman, Bonita x Hegari and Queensland Kalo. Ladone is somewhat tall for combining, but the three other types, which are well suited for this purpose at Tozi, were bulked under irrigation in the dry season for production in 1954.

In 1951 selection of combine types began in Wad Akr and Feterita Maatuk. In 1953 over 500 lines of the former, from 1952 progeny rows, were sown at Tozi, and proved remarkably uniform, with a height of about 4½ ft. High yielding lines, some of which gave over 3500 r.p.f., were selected and the remainder (2.2 feddans) was combined. The yield was 2645 r.p.f., but because of lodging only 1840 r.p.f. of this was taken by the combine. The lines proved slightly too tall for efficient working of the machine, but it is now known (1954) that this is a factor affected by planting date in this variety.

The Feterita Maatuk progenies were further selected into 4 height groups.

Of selections made in 1952, those from Feterita Geshesh and Feterita Wad Umm Benein had characteristically good extrusion of the heads ; Wad Yabis and Mugbash appeared to be excellent yielders. Further selections were made in these varieties.

100 plants of each of six Fung varieties, and a large number of offtype dwarf individuals from the Fung material, were selected in 1953 for further work in 1954.

The Kaoliang x Combine 60 and Kaoliang x Martin crosses were grown once more and selections were made for resistance to lodging.

Table 10.

Yield and plant population of 16 varieties of sorghum, Tozi, 1953.

Summary of results.

Variety.	Grain, r.p.f.	Plant population 000/fedd.
	(± 36.6)	(± 0.76)
Wad Beshir	2717	31.0
Swaziland P. 41	2698	35.2
Ladone	2550	33.5
Plainsman	2400	33.5
Bonita X Hegari	2326	35.2
Queensland Kalo	2233	30.1
Oklahoma	2047	29.3
Redbine 66	2028	26.8
D. Dwarf Shallu 6399-3	2028	39.3
Redbine S.A. 5507-41-2-15	1991	33.5
Combine Kafir 60	1954	20.9
Redbine 60	1749	36.8
Red Combine	1581	25.1
Texioca 54	1526	26.8
Midland	1507	27.6
Combine Kafir 54—T	1321	30.1
Mean	2041	30.9
Least significant differences:		
5 %	105	2.3
1 %	142	3.1
0.1%	189	4.1

Cotton.

Of six varities of American cotton compared in a variety trial (table 11) BAR. 7/8.1 and BAR. 7 8.2 were the most successful (481 and 466 r.p.f. on lint). Punjab 268F gave an equally high yield (460 r.p.f.) of poor quality lint.

Table 11.

Yield and plant population of 6 varieties of cotton, Tozi, 1952.

Variety	Yield of Lint. r.p.f. (unadjusted)	Yield of Lint Adjusted for plant population r.p.f.	G.O.T.
	(± 18.2)		
BAR 7/8.1	472	481	35.0
Punjab 268F	469	460	33.0
BAR 7/8.2	460	466	34.9
Mu8b	413	415	34.7
BAR SP84	344	348	29.6
Pump Scheme	338	326	28.8
Mean	416	416	32.7
Significant difference :			
5%	54	51	
1%	73	69	
0.1%	97	92	

Groundnuts.

Work on the classification of varieties of this crop was carried further. (The tentative classification developed was considerably modified in 1954 and is accordingly not presented here. The final classification has been accepted for publication).

In observation plots planted 16-18 July yields up to 1230 r.p.f. of kernels were obtained from both long and short season forms. In a formal trial planted on 27-30 July to compare 25 short season varieties, several types did better than the standard Natal Common used in production, having regard to their populations. Among them were Barberton and B 725.

Sesame.

In the collection (65 varieties) Mafaza light gave the outstanding yield of 1385 r.p.f. in an observation plot. Other varieties ran up to 1100 r.p.f. In general, in this rather dry season (590 mm.), varieties derived from the drier parts of the Sudan, with less than 700 mm. average rainfall, did better than varieties from wetter areas. The respective means were 955 and 779 r.p.f. In 1952 (total 702 mm.) the positions were the other way about, with means of 380 and 452 r.p.f.

In a formal trial, which did not include Mafaza light, varieties from Qala en Nahl and Medium white yielded 780-850 r.p.f., significantly better than all other varieties tested.

In the field of sesame breeding, the selections made in 1952 in Early Resistant White for capsules with 8 locules instead of the normal four bred true in progeny rows, and the 10 rows with the highest capsule numbers per plant were selected and bulked. Further selections of dwarf early flowering types derived from the American ECR 972 were made. The progenies of several crosses were taken through two more generations using the irrigated area for a dry season generation. Selections were made of material containing the Venezuelan indehiscent character, and lines free from undesirable associated characters, and apparently suitable for backcrossing, were isolated. F1 progenies of a cross between a Sudanese type and an introduced dwarf variety with 3 capsules per axil did not show the marad ed damm resistance of the local parent, while in the F2, raised in the dry season, the attack was too light to demonstrate differences.

Safflower.

Yields up to 800 r.p.f. were obtained in observation rows and CT63 was again one of the more successful varieties. Selections were made of early maturing plants in the very mixed spineless farm stock.

Sunflower.

In 1952 a number of lines were selected which appeared to have a high capacity for self fertilisation under selfing bags. The progenies of these selections were not impressive, but some lines which had been open pollinated in 1952 did well in bags in 1953. It is felt that the character exists though its genetics are not simple. Methods of bagging which avoid all possibility of mechanical transfer of pollen by the bag will aid greatly in this work.

Soya.

Yields of this crop up to 900-1000 r.p.f. were obtained on observation rows and a variety trial but the seed was of poor quality and much damage was done by termites.

Tobacco.

Both Virginia and Turkish varieties were planted out from the seed bed towards the end of the rains into observation plots with different fertiliser treatments. The plants grew on into January, giving dark heavy leaves of poor apparent quality and showing signs of high N K imbalance.

Castor.

Negligible yields were obtained from 7 varieties. Work on this crop is to be discontinued.

Botanical and soil surveys of the region from Jebel Moya to the Ingessana hills, and of the farm in more detail, have indicated a general relationship between topography (as it affects wetness of the situation) and rainfall, on the one hand, and soil and vegetation type on the other. In wetter situations soils are darker in colour. Small variations in slope affect the hydrologic situation considerably and so the boundaries of soil types and of soil vegetation units are often indistinct.

Four main communities occupy land of agricultural significance. The *Acacia mellifera* thicket on brown soils lies mainly north of the 600 mm. isohyet and contains areas of annual grassland. *Acacia seyal* woodland with *Balanites aegyptiaca* (heglig), *A. senegal* (hashab) and *Zizyphus* sp. (sidr) occur on grey brown soils south of the 600 mm. isohyet. The open annual grassland associated with this vegetation type contains typically *Sorghum purpureo-sericeum* (anis) and has affinities with the Gedaref grasslands. *Acacia fistula* (sofar) woodland, which includes *A. drepanolobium* communities, occupies relatively wetter, darker soils, and in the wettest areas there are treeless open grasslands of umm chirr, *Brachiaria obtusiflora* on grey soils. The broad leaf deciduous woodland, with *Combretum hartmannianum* and an increasing number of other species in wetter areas, occurs south of the 750 mm. isohyet on the clay soils.

Weeds.

Most of the important weeds of farm crops at this early stage are annuals. *Ipomoea cordofana* (tabr), with long procumbent stems was the most important perennial. Seid grass (*Cyperus rotundus*) and dingel (*Cephalocroton cordofanus*) were only locally important, and there was some regeneration of *Zizyphus* sp. (sidr) and *Acacia campylacantha* (kakamut) on cleared land.

Suckers originate from the roots of tabr (*I. cordofana*) at depths up to 33 cm., as rainfall penetrates at the beginning of the season, so that it is not eradicated by early discing alone. Thus early planted crops on new land may become badly infested with this weed, whose trailing stems impede mechanical weeding. Bare fallow fields on new land were kept free of weeds by 4 or 5 discings. On second year land weeds were much fewer and complete control was obtained by machinery in some fields, apart from light hand weedings in the row. Tabr and many other species are very readily eliminated by close control in the first year, and tabr itself is easily controlled with 2 : 4-D at 0.5 r.p.f. Tumbledown fallowing is a dangerous source of re-infestation.

Buda (*Striga hermonthica*) was very rare in fields at Tozi in 1953, though present or common in wild vegetation or village fields.

Root developments of crops.

The vertical penetration of roots of sesame (local black) and groundnuts (Natal Common) was followed in a series of pits until the end of September. Generally the roots followed the moisture into the dry soil until the zone of persistent moisture was reached (about 80 cm.). The groundnut roots penetrated to 97 cm. and the sesame roots to 84 cm. in all.

Cotton defoliation.

Cotton was successfully defoliated by 15 or 30 r.p.f. of a proprietary chlorate-borate mixture (Shedaleaf) provided it was applied before the seasonal humidity drop towards the end of October. The yield was however reduced by 190-270 r.p.f. seed cotton by the treatments. Evidently the advantages of mechanical picking would have to be very great to make such losses worth while, though of course less costly methods of defoliation may yet be found.

Forage plants.

11 Local and 9 introduced species of legumes were planted in observation plots. The local perennials *Vigna* spp., *Tephrosia* sp. and both local and introduced *Clitoria ternatea* seemed the most useful. Various mixtures of legumes and Wad Akr sorghum were grown as possible silage material.

13 species of grasses were planted in the hope of finding a suitable prostrate or partly prostrate perennial for use in pasture mixtures or to replace the local upright annuals such as anis (*S. purpureo-sericeum*). The local varieties of *Chloris gayana* (Rhodes grass) and *Cynodon dactylon* seemed most promising, and *Panicum coloratum* (Makarikari grass) a valuable semi-prostrate type from roughly corresponding ecological sites in southern Africa, seemed to deserve further attention.

Two cuttings, on 16 August and 12 September, were shown to stop flowering in anis grass. This suggests that the value of this species for grazing is strictly limited, and that it could not usefully form a self-sowing component of a permanent pasture. The interest in prostrate or semi-prostrate types is thus further emphasized.

Acacia senegal (hashab) garden.

A plot of gum arabic was established using seed treated for 10 minutes in concentrated sulphuric acid, which gave 89% germination, though 13 or 15 minutes treatment gave 24% and 1% germination respectively. Untreated seed gave 22%. Survival of the seedlings was however poor and many were attacked by termites.

Plant Pathology.

The 1953 season at Tozi was remarkable for the almost complete absence of disease in adult plants. Seedbed diseases were again important.

Cotton.

Angular leaf spot due to *Xanthomonas malvacearum* was widespread but slight in the resistant BAR. 7/8.1 grown at Tozi, though some few cases of blackarm occurred. In a variety trial BAR. 7/8.2 and Punjab 268F also showed high resistance, while BAR. SP 84 was mildly and MU 8b and Pump Scheme markedly susceptible. Leaf curl was not seen on cotton at Tozi in 1953.

Groundnuts.

Seedbed losses in groundnuts were found, as in East Africa, to be largely due to the fungi *Rhizopus* spp., *Aspergillus niger* and *A. flavus*. *Rhizopus* is responsible for losses in the early stages of germination and may cause much damage if emergence is delayed by unfavourable soil conditions. A detailed study of the effects of seed dressings on groundnut seedbed losses is discussed below under the heading of entomology.

In bulk plantings seedbed losses were about 30% ; and post emergence losses by *A. niger* and *flavus* (crown rot) perhaps another 10%. Losses of this magnitude make the attainment of the high populations indicated as necessary by the agronomic investigations extremely difficult.

Rosette disease was again absent from the region. Cercospora leafspots (both *C. personata* and *C. arachidicola*) were widespread but slight, the Valencia types being more susceptible than others. The systemic leaf scorch of legumes seen in 1952 did not reappear.

Sesame.

Marad ed damm, a leaf necrosis probably of bacterial origin, was widespread but not severe except on certain hybrid material containing the Venezuelan indehiscent character. Early Resistant White (ex Kadugli) maintained its resistance and was also somewhat resistant to *Oidium*. In a low infection in the F2 of E.R.W. x an early dwarf American form no segregation of resistance could be detected.

Leaf debris which had been exposed throughout the dry season to the high surface temperature was still highly infective in June, producing marad ed damm lesions in 7 days. Spread from these plants to leaves at the same level on adjacent plant occurred in another 5 days. The infection seems to spread by rainsplash.

Other diseases were a damping off in densely planted seedbeds, a leaf curl, the downy mildew (*Oidium*) already mentioned, which was partially controlled by a copper spray (Perenox) and a *Cercospora* leaf spot.

Sorghum.

Pre-emergence seedbed losses were severe, approaching 60%, and post emergence losses accounted for 30%, of the seed sown, so that most stands were very poor. No specific disease could be found, but it is shown below that insecticidal treatments control these losses. This is the most serious plant protection problem in this crop.

Four leaf spot organisms were present but did little damage. *Sphacelotheca sorghi* (covered smut) occurred in some local varieties and in fields planted with seed imported from elsewhere, and the affected heads were all removed. Areas planted with Tozi seed were free of the disease though the seed was not dusted, the roguing of the previous season having been effective. In some cases lodging at maturity was found to be associated with charcoal rot (*Sclerotium bataticola*).

Other crops.

The soya bean varieties Nanda and Glycine 27 maintained their resistance to bacterial leaf spot (*X. phaseoli*). Streak was seen rarely in maize, and *Puccinia sorghi* occurred in the district. *Helminthosporium* was also present, but none of these diseases was in any way serious in 1953.

Entomology.

Except for the role of insects in seedbed losses of groundnuts and sorghum, serious insect damage to crops at Tozi in 1953 was confined to termite attacks on maturing groundnut pods, some localised grasshopper attacks on sorghum at the end of the season, and sorghum midge infestations.

Cotton.

Pink, American, Sudan and Egyptian bollworms were all present, and attacked about 14% of flowering points. Other caterpillars were negligible and thrips, though present on groundnuts, did not appear on cotton.

Groundnuts.

Where groundnuts were grown in 1953 after 1952 groundnuts, an average of 13,500 plants only was established from over 50,000 seeds sown per feddan. On new land, or after other crops, the stands averaged 17,000 plants per feddan. Even this loss is heavy and costly and the population is too low for the best yields. To study the problem in more detail a combined insecticide fungicide experiment was set out (table 12) on land which had carried groundnuts in 1952. All combinations of the presence and absence of 2 fungicidal seed dressings (Agrosan at 4 oz./ cwt and Perenox at 8oz. / cwt of seed) and of three insecticide treatments (B.H.C. or dieldrin applied to the soil at 1.5 r.p.f. and dieldrin applied to the seed at 1 part per thousand, active ingredients in each case) were tested. Planting was late (early August) to maximise the effects.

Table 12.

Effect of soil insecticide and seed fungicide and insecticide treatments on emergence, thrip damage, harvest population, yield and termite damage, groundnuts, Tozi 1953.

Treatments : Agrosan or Perenox as seed dressings at 4 and 8 oz./cwt of seed respectively, B.H.C. or dieldrin applied to soil at 1.5 r.p.f. active ingredient or dieldrin applied to seed at 1/1000 w/w active ingredient.

Variety : Barberton

Fungicides	Insecticides. None	Dieldrin seed	BHC soil	Dieldrin soil	Mean
I. Population at 15 days, 000/feddans:					
	(±0.87)a		(±1.93)b		(±0.68)c
None	13.5	22.8	18.7	18.5	18.4
	(±1.93)b				(±0.97)d
Agrosan	17.4	26.1	26.0	24.3	23.4
Perenox	19.0	26.6	26.0	22.3	23.5
	(±0.73)e		(±1.12)f		
Mean	16.6	25.2	23.6	21.7	21.8
Least significant differences :—	b	a-b	d	c-d	f	e-f
5%	5.5	4.3	2.8	2.9	3.2	2.7
1%	7.4	5.8	3.7	3.2	4.3	3.6
II. Thrips scores + at 1 September :					
None	9	6	3	0	4
Agrosan	10	7	3	0	5
Perenox	10	7	3	0	5
Mean	10	7	3	0	5
III. Thrips scores + at 19 Oct.:					
None	12	11	6	1	8
Agrosan	15	10	2	1	7
Perenox	14	11	5	1	8
Mean	14	11	4	1	8
IV. Population at harvest, 000/fed.					
	(±0.70)a		(±1.56)b		(±0.55)c
None	11.1	19.6	16.2	16.4	15.8
	(±1.56)b				(±0.78)d
Agrosan	14.8	20.9	21.6	20.6	19.7
Perenox	14.6	21.1	21.6	17.8	18.8
	(±0.59)e		(±0.90)f		
Mean	13.5	20.5	19.8	18.3	18.1
Least significant differences :	b	a-b	d	c-d	f	e-f
5%	4.5	3.5	2.2	1.9	2.6	2.2
1%	6.0	4.6	3.0	2.5	3.5	2.9

+ Higher score = more damage .

Fungicides	Insecticides.				
	None	Dieldrin seed	BHC soil	Dieldrin soil	Mean
V. Yields, kernels r.p.f.:—					
None	(±22.3)a 505	845	(±49.9)b 826	899	(±17.6)c 769
Agrosan	(±49.9)b 577	817	868	944	(±25.0)d 802
Perenox	558	781	833	960	783
Mean	(±18.9)e 547	814	(±28.8)f 842	934	784
Least significant differences:—	b	a-b	d	c-d	f	e-f
5%	143	111	72	62	83	70
1%	192	149	96	83	111	94
VI. Loss by termites, estimated, kernels r.p.f.:—					
None	(± 7.1)a 95	80	(±16.0)b 51	25	(±5.6)c 63
Agrosan	(±16.0)b 95	78	36	8	(±7.9)d 54
Perenox	80	94	46	8	57
Mean	(±6.0)e 90	83	(±9.1)f 44	14	58
Least significant differences:—	b	a-b	d	c-d	f	e-f
5%	46	35	23	19	26	22
1%	62	47	31	26	35	30
VII Assumed total yield, including estimated loss, r.p.f.:—					
None	600	925	877	924	832
Agrosan ...	672	895	904	952	856
Perenox ...	638	875	879	968	840
Mean	637	897	886	948	842

In the absence of any treatment 13,500 plants/feddan were established at 15 days. When used alone, the soil insecticides gave 5000 extra plants, but dieldrin applied to the seed gave 9000 extra plants. Fungicides alone gave around 5000 extra plants: when in addition an insecticidal treatment of any sort was given the level of population was similar to that obtained with the dieldrin seed treatment alone.

The insecticides, but not the fungicides, gave a measure of control of thrips, and the soil treatments, particularly dieldrin, were more effective than the dieldrin seed treatment. The dieldrin/soil treatment kept the plants virtually free of thrips throughout.

During the life of the crop a steady loss of plants occurred, which although rather heavier where the emerged stands had been higher, was not sufficiently so to obliterate the effects of the original treatments, so that the dieldrin seed treatment was still the most successful, particularly where no fungicide had been used.

The effects of the insecticides on yield, however, were most striking. Where no treatment had been given the yield was just over 500 r.p.f. of kernels. Fungicides alone gave 60-80 extra rotls kernels only: insecticides gave 340—400 rotls extra and in the case of the soil insecticides the effects were roughly additive, so that yields were raised to 900—960 r.p.f. Of the soil insecticides dieldrin was more effective than B.H.C., which it outyielded by about 100 rotls kernels per feddan. Thus the effects of the insecticides on yield were out of all proportion to their effects on population. This was partly due to the control of termite damage (obtained from the proportion of sound to damaged nuts and their respective shelling percentages) but was probably primarily due to control of thrips. The dieldrin soil treatment controlled termites as efficiently as it controlled thrips.

This experiment indicates the importance of soil insecticides in groundnut production and suggests that dieldrin is an effective material deserving further study. The control of termite damage is noteworthy as these insects also attack many other crops in the Sudan.

The results just discussed were obtained on land which had carried groundnuts in the previous year. A second experiment designed to measure residual effects of dieldrin, aldrin and B.H.C. as soil insecticides was set out on new land (table 13). Aldrin was applied at 4 oz. and 2 rotls per feddan and B.H.C. and dieldrin at 1 and 2 r.p.f. active ingredient.

Table 13.

Effect of insecticides on yield and termite damage, groundnuts, Tozi, 1953.

No insecticide		Aldrin	BHC	Dieldrin
I. Yield, Kernels, r.p.f.			(±38)a	
Lower rate		785	707	886
Higher rate		826	810	895
			(±26)b	
Mean	757	805	759	891
Least significant differences:		a	b	a-b
5% ...		106	76	92
1% ...		143	99	124
II. Loss of yield by termites, estimated, r.p.f.			(±8.6)a	
Lower rate		78	105	35
Higher rate		44	60	26
			(±6.1)b	
Mean	77	61	83	31
Least significant differences:		a	b	a-b
5% ...		25	18	21
1% ...		33	24	29
III. Pods atacked by termites, 000/feddan.			(±6.2)a	
Lower rate		76.8	84.1	28.2
Higher rate		44.6	48.1	21.1
			(±4.4)b	
Mean	64.1	60.7	66.1	24.7
Least significant differences:		a	b	a-b
5% ...		27.1	13.1	23.6
1% ...		36.3	17.6	31.6

The yield differences were small, and apparently largely due to termite control, in which dieldrin was the most effective material, followed by aldrin and B.H.C. in that order. With no insecticide 760 r.p.f. of kernels were harvested : dieldrin gave 890 r.p.f. even at the lower rate (1 r.p.f.) of application.

Sorghum.

Work by Tarr in other areas of the Sudan rainlands has previously shown that small seed dressings of B.H.C. of the order of 2 gm.feddan active material greatly improve the emergence of sorghum. At Tozi in 1953 a series of micro-plot experiments confirmed this finding. In the absence of insecticides 6% of the seeds emerged. B.H.C. as a seed dressing raised this figure to 84%. Dieldrin, whether at 1 1000 or 1/250 active ingredient w/w, gave 72% emergence. B.H.C. applied in the row at 1 r.p.f. was toxic (1% emergence) but dieldrin applied in the same way gave 80% emergence whether applied at 0.1 or 1.0 r.p.f.

The organism responsible for these effects is not known, though cockchafer grubs are suspected in the Gezira, where somewhat similar effects have been found. Where seed had been protected in this way at Tozi the characteristic post-emergence known as hurug or Camp 8 disease did not appear.

Other pests of sorghum were sorghum midge (*Contarinia sorghicola*) against which the use of early flowering varieties seems the best defence ; and grasshoppers (*Aiolopus savignyi*) which reached Tozi with the north wind at the end of October and did some damage in small localised areas.

Other crops.

In sesame pest attacks were light. Webworm was more conspicuous on the indehiscent varieties. Okra (*Hibiscus esculentus*) and kenaf (*H. cannabinus*) were heavily attacked by flea beetle (which could be checked by D.D.T. spraying), though cotton was unaffected.

Farm Operations and Mechanisation.

In 1953 the mechanised production of field crops was undertaken at Tozi on a considerable scale. Sowing and weeding of cotton ; sowing, weeding and harvesting of sorghum; sowing, weeding, ridging, digging, side-raking and threshing of groundnuts ; sowing of sesame ; and sowing and harvesting of safflower were all performed mechanically in addition to primary cultivations and seed bed preparation.

It seems unlikely that cotton will be picked mechanically in the Sudan on any scale in the near future. The loss of yield by defoliation, the problems of cleaning and of possible damage to lint, the cost and intricacy of the machinery, and the traditional place of cotton picking in the economy of many areas of the Sudan would all appear to indicate hand picking as the method of choice for the present. Nevertheless it would be of great interest to test a cotton picker in the Sudan rainlands to gain technical data on the method.

Field yields of seed cotton ranged from 316 to 768 r.p.f. with a mean around 500 r.p.f. In experiments, values up to nearly 1400 r.p.f. were obtained with early planting, adequate populations and efficient weed control.

In groundnuts the principal difficulty is the establishment of high populations against the serious seed bed losses. The field yields ranged from 475 to 685 r.p.f. of kernels with a mean around 570 r.p.f. In experiments yields up to 1100 r.p.f. were obtained.

The sorghum crop also presented great difficulties in establishment, though it now seems likely that these will be overcome with insecticidal seed dressings. The yields ranged from 580 to 1350 r.p.f. of grain on 4 fields : none of these results can be considered satisfactory. However a small experimental field (over 2 feddans) of experimental Wad Akr sorghum, with a high population, gave over 1 ton/feddan (see above, Plant Breeding Section).

Sesame has to be grown on clean land since it does not appear possible to weed the crop mechanically because of the small size of the seedlings in the early stages. Harvesting is by hand though a reaper binder might be used. Field yields were 230—550 r.p.f. only, and experimental results indicate that considerably higher yields are to be expected as the technique of production is improved.

In the absence of experimental evidence on rotations, two principal sequences are in use at Tozi in the management of the fields. They are :—

bare fallow — cotton — groundnuts — sorghum

safflower — sesame — groundnuts — sorghum

The principle of the first is to give the most valuable crop the benefit of clean land and accumulated moisture, and to interpolate the groundnut crop between cotton and sorghum. In the second the land is semi-fallowed for the safflower, which has to be planted late and then dries out the accumulated water, so that the following sesame has a clean, dry seed bed. Once again sorghum is preceded by groundnuts, which appears to be a suitable arrangement from the result of the single crop sequence experiment so far completed.